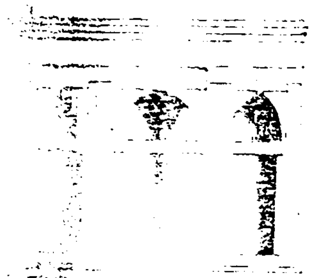
The Center for Naval
Warfare Studies

UNDERSTANDING ENVIRONMENTAL SECURITY: A MILITARY PERSPECTIVE



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Advanced Research Project
Spring 2000 - #4

U.S. Naval War College

UNCLASSIFIED
Security Classification This Page

REPORT DOCUMENTATION PAGE

1. Report Security Classification: UNCLASSIFIED			
2. Security Classification Authority: N/A			
3. Declassification/Downgrading Schedule: N/A			
4. Distribution/Availability of Report: UNLIMITED			
5. Name of Performing Organization: Advanced Research Department			
6. Office Symbol: 35	**7. Address:** NAVAL WAR COLLEGE 686 CUSHING ROAD NEWPORT, RI 02841-1207		
8. Title (Include Security Classification): "Understanding Environmental Security: A Military Perspective"			
9. Personal Authors: W. Chris King, COL, USA			
10. Type of Report: FINAL	**11. Date of Report:** 14 June 2000		
12. Page Count: 133			
13. Supplementary Notation:			
14. Ten key words that relate to your paper: Environmental Security, Military has an important but supporting role in United.States environmental security.			
15.Abstract: Environmental security is a topic of growing interest in national security affairs and thus has significant implications to the military national defense mission. In the context of this report environmental security is a process of addressing those environmental issues having the potential to cause crisis or conflict to such an extent that they represent a threat to t he security of the US. The major products of this research are: A layman's description of the science of the major environmental degradation and resource scarcity issues in the world, a strategic threat assessment of the risk of these issues, a delineation of environmental security into the military and civilian security missions, and identification of possible military supporting role missions in environmental security. Geographic Information Systems (GIS) analysis was applied to correlate regional environmental scarcity and degradation issues. This analysis of the major issues determined that the best predictive metric of environmental degradation is rate of deforestation and water scarcity. All data reflected that population evaluated on the basis of regional carrying capacity best determined the overall stability of a region.			
16.Distribution / Availability of Abstract: A	**Unclassified** **X**	**Same As Rpt** **X**	**DTIC Users**
18. Abstract Security Classification: UNCLASSIFIED			
19. Name of Responsible Individual: Professor John B. Hattendorf, Director, Advanced Research Department			
19.Telephone: 841-6020	**20.Office Symbol:** 35		

Security Classification of This Page Unclassified

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Understanding Environmental Security: A Military Perspective

by

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This paper was completed as an independent research project in the Advanced Research Department, Center for Naval Warfare Studies, Naval War College. It is submitted to the Faculty of the Naval War College in partial satisfaction of the requirements of the Master of Arts in National Security and Strategic Studies. As an academic study completed under faculty guidance, the contents if this paper reflect the author's own personal views and conclusions, based on independent research and analysis. They do not necessarily reflect current official policy in any agency of the U.S. government

Advanced Research Project
Spring Term, Academic Year 1999-2000
14 June 2000

UNDERSTANDING ENVIRONMENAL SECURITY: A THE MILITARY PERSPECTIVE

EXECUTIVE SUMMARY

Environmental security is a topic of growing interest in national security affairs and thus has significant implications to the military national defense mission. In the context of this report environmental security is a process of addressing those environmental issues having the potential to cause crisis or conflict to such an extent that they represent a threat to the security of the United States. The major products of this research are: A layman's description of the science of the major environmental degradation and resource scarcity issues in the world, a strategic threat assessment of the risk of these issues, a delineation of environmental security into the military and civilian security missions, and identification of possible military supporting role missions in environmental security. Geographic Information Systems (GIS) analysis was applied to correlate regional environmental scarcity and degradation issues. This analysis of the major issues determined that the best predictive metric of environmental degradation is rate of natural population growth. Strong correlations were found between this statistic and rates of deforestation and water scarcity. All data reflected that population evaluated on the basis of regional carrying capacity best determined the overall stability of a region.

The major conclusions of this report are:

- Environmental security needs to a component of the overall national security mission.
- The military have an important, but supporting role in U.S. environmental security initiatives.
- Population growth rates are the best predictive metric for assessing regional environmental stability.
- Areas of Central and North Africa, the western Pacific Islands, Ganges River area, and parts of Central America and South America are least stable regions from an environmental security standpoint.
- Regional threat analysis can be most effective conducted by geographic CINCs with more detailed data regional data, following the model developed as part of this research.
- The Theater Engagement Planning Process is the appropriate military planning system for environmental security mission planning.

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Chapter 1

INTRODUCTION

A. Preface

What is Environmental Security?

What is the military mission in environmental security and how should we be executing this mission?

Succinctly stated, these are the questions that this project intends to address. *Environmental Security* is a term one now hears regularly bantered about by senior leaders involved in national security and defense affairs. Does this mean that *Environmental Security* is now an integral part of the way the United States conducts its national security business, or is it a term of fashionable jargon enjoying its brief state of acceptance in defense culture, as often happens. Bernard Brodie, a noted scholar on war, in a speech at the Army Command and General Staff College once made a prophetic comment about the misuse of 'jargon'. He stated.[1] " *It* (jargon) *gives us a sort of shorthand, wherein a mere phrase can convey a very considerable body of thought and mutual understanding, which is of course characteristic of specialized vocabularies in all sciences. The function of jargon is, to be sure, frequently abused by scholars who have forgotten how to write or think in English.*" Without any evidence to support my view, I believe Professor Brodie had a point in expressing this view to his military audience, and it was not to further their dislike of 'academics'. The military often use jargon without the requisite 'mutual understanding' and this is specifically true in today's use of the term, *Environmental Security.* In my

[1] Brodie, Bernard "The Worth of Principles of War" from a lecture delivered on 7 March 1957 to the U.S.Army Command and General Staff College, Fort Leavenworth, KS.

military experience I have heard the term used by numerous senior Department of Defense officials, each obviously using the term in a different context. This doesn't mean that any of these senior officers were wrong, but reinforces that environmental security means different things to different people and therefore must be employed with care. The next chapter is devoted to sifting through the numerous definitions for environmental security available in military and academic writing today to formulate a definition of environmental security specific to the purpose of this study.

This project began based on my personal definition of environmental security founded on the belief that there are dramatic man-induced changes occurring in our environment that are adversely impacting our earth today, which left unabated will seriously impact the safety and security of our world. A burgeoning population and its demands for natural resources, renewable and non-renewable, is leading this assault on the environment. Some consider technology as a co-conspirator in this degradation of the environment. Certainly technology has evolved to the point that it can do great harm, but technology can also heal and mitigate. With these constraining comments the overarching theme for this paper becomes.

Environmental degradation and environmental resource scarcity are of a magnitude that they can become, if they are not already, an issue of national security for the United States.

B. Background in Environmental Security Studies

The theme for this project not a new concept, particularly to the academic community where the environmental movement began. Many of the eminent scientists who advanced our understanding of the earth's environment were also the 'doomsayers' (as they were characterized in their time) predicting catastrophic consequences on the environment from man's activities. A number of these scholars further conceptualized their views of environmental security couched in the old civics debate, what should the government buy, 'guns or butter'. Norman Myers, one of the early environmental security scholars, espoused this view when in 1986 he wrote, [2]

> *"Hence national security is not just about fighting forces and weaponry. It relates to watersheds, croplands, forests, genetic resources, climate and other factors that rarely figure in the minds of military experts and political leaders, but increasingly deserve, in their collectivity, to rank alongside military approaches as crucial in a nation's security."*

In hindsight, it certainly appears that Myers was dead on target at least in identifying future ***Environmental Security*** issues. It is also understandable that military leaders did not embrace his concepts, considering Myers' view that reduced military spending was the appropriate source for environmental security funding.

Today, the environmental security debate flourishes among social and political science scholars who work to redefine security, define environmental security, and understand the political and social responses to environmental scarcities. Within the forum developed at the Woodrow Wilson International Center for Scholars' organized as the

[2] Norman Myers, The Environmental Dimension to Security Issues, (The Environmentalist, 1986), 251.

Environmental Change and Security Project, debate and discussion continue. Thomas Homer-Dixon[3], Marc Levy, and others have helped evolve and focus the early work of Norman Myers[4] and other scholars into our basic understanding of how environmental issues can/will impact security in the future. It is not a goal of this report to enter into this fray. The debates here center more on the political science of defining security and applying the political sciences to analyze how developing countries will respond to any environmental stress factors.

Previous research does offer important inputs into this research focused on advancing our understanding of what the military mission should be. This body of work aids in identifying what, if any, of our worldwide environmental responsibilities are security concerns, and therefore should thread through our National Security Strategy into the National Military Strategy. However, the analysis here becomes truly convoluted within the political and social dimensions of government. The overall lack of an worthy adversary for the US in a world without an Iron Curtain and a Cold War has caused problems. Because of these bigger picture problems we struggle with identifying and prioritizing those issues such as environmental security which here to fore have been lesser concerns.

Predicting global climate change is tough, but this environmental debate pales in light of the rhetoric concerning the new balance of power and security threats emerging as the political geography of the world restructures itself, mostly at the point of a gun. Samuel Huntington in his best selling, **The Clash of Civilizations and the Remaking of the World Order**[5], offered a brief review of the prevailing theories that explain the political changes in

[3] Thomas Homer-Dixon, Environmental Scarcity and Global Security,(Foreign Policy Ass., USA, 1993).
[4] Norman Myers, Ultimate Security: The Environmental Basis of Political Stability, (Norton, 1993).
[5] Samuel Huntington, , The Clash of Civilizations and the Remaking of the World Order, (Simon and Schuster, NY, 1996).

the world today, and in the future. Of course this review was a precursor to his presenting his theory on the subject. Debating these different theories of political science is outside the scope of this project, but disappointedly, neither Huntington's nor any of the other theories he reviewed overtly considered environmental degradation as a primary source of conflict. Many of the theories, the Sheer Chaos Paradigm for example, have underlying threads in many of the environmental issues we will be discussing, but this theory suggests that everything else in the world is going to be so awful that environmental chaos will be hardly noticeable. Accepting the Huntington view here would make this a relatively short essay, since none of the environmental issues would have a security component. However, there are others[6] including this author that disagree, disagree to the point of purporting that environmental issues may be a major sources of conflict in the world. White in his, **North South, and the Environmental Crisis**[7], sees the issue divided by hemispheres. The sources of conflict from this view are the cumulative impacts of the environmental issues exacerbated by population growth and poverty in the Southern Hemisphere. Of U.S. political leaders Vice President Gore is one of our most knowledgeable national leaders on this subject and he is deeply concerned with the potential damage to world order being manifested by environmental degradation[8]. The literature is resplendent with other predictions of conflict over environmental issues, but the more positive evidence is in the records of actual conflict.

The best compilation of data has been for the conflicts over water. Dating back to 2500 BC, water has truly been something people will fight over. Over the period 1945 – 1997, Gleick identified 17 distinct incidents of armed conflict directly over access to water

[6] Ambassador Richard Armitage, very senior US diplomat and strategic analyst specifically disagreed with Huntington's view on causes of insecurity, and listed environmental concerns such as water scarcity as looming threats. 23 May 2000 lecture to the Naval War College.
[7] Rodney White, North, South, and the Environmental Crisis, (University of Toronto Press, 1993).

for human use[9]. While direct causal relationships between other environmental issues and conflict are less well established, as the magnitude of these problems increase it is certainly plausible that they too could degenerate to conflict. Lee has identified 70 separate modern era conflicts with which he associates some environmental issues to their causation[10]. One impact already seen is what United Nations characterize as **environmental refugees**, people displaced by the combined effects of population growth, resources scarcity and disease[11]. The military and security repercussions of these refugee problems are already documented in military after action reports from Rwanda. Somalia. Ethiopia. and the Sudan.

C. Our Obligation

It is fairly clear that environmental degradation and scarcity are going to be a problem for some people in the world. but one attitude could be that it is not our problem because the U.S. possesses adequate resources and employs sound conservation measures. In another line of reasoning. use of any military capacity for international environmental security further hampers readiness and heaps more on an already overtaxed military. Why should the U.S. and specifically for this study. U.S. Armed Forces become involved? There are three lines of analysis addressing this question and they all lead to the same conclusion. The three rationales are 1) It is the moral responsibility of the United States. 2) It is an obligation we have incurred, and 3) Practical self-interest dictates it as the prudent action.

The moral approach is based on a belief America is great because we support and defend high ideas for all people. We continue to send troops into harm's way in cases where

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[8] Albert Gore. Earth in Balance, (Houghton-Mifflin, Boston. 1992).
[9] Peter Gleick. The World's Water, 1998-1999, (Island Press. 1998), 125-130.
[10] James White. Inventory of Conflict and Environment, AEPI. April 1999).
[11] Rodney White, North South, and the Environmental Crisis, (University of Toronto Press. 1993). 96-97.

our primary rationale is our belief in the basic rights of all people. Actions in Kosovo, protecting the Kurds, assisting refugees in Rwanda are all examples of military actions primarily driven by our moral precepts. As we will see as this study develops, the environmental scarcity and degradation issues are more threatening to more of the innocent population of the world that all of the landmines and AK-47s ever made. This is a rationale well described by many scholars and in the final analysis is the overriding basis for the Vice President's call to action. It can be said that the first requirement to be a superpower is to be willing to act like one; to lead when the world has issues that require someone bringing the world together.

No country in human history has ever so dominated the world in economic and military power has the United States does today. In doing so we consume a vast quantity of the world's renewable and non-renewable resources and produce more waste than anyone else on earth. The Army has a down-to-earth idiom that suggests, for their own good, troops should keep their mess kits clean; this is also true for the United States and the importance of the rest of the world in sustaining our way of life. Through our demand for resources and production of waste we have incurred an obligation to sustain the global environment, and will need to participate in world efforts to reduce our impacts and demands on the world environment, which becomes a component of our environmental security strategy.

The third line of reasoning is the pragmatist's view of the world, environmental security is in our own best interest. The cost of cleaning up a mess is always higher than the cost of prevention. Trying to rebuild a denuded forest or restore a water supply are costly activities compared to educating people on sustainable development or measures to prevent water pollution. More directly to the issues of this study, the cost of war resulting from environmental scarcity issues will be greater than many of the actions that can be taken to prevent conflict.

One should reach the same conclusion whether you approach from the view of our position as a world power, or from the view of an accomplice in the crimes polluting the world environment -- U.S. interests dictate that environmental security must be considered in national security policy making. Even under the uncertainty associated with many of the environmental issues, the body of evidence confirming that humans are adversely impacting the environment on a global scale is irrefutable. Depletion of stratospheric ozone and the destruction of the Aral Sea are just two examples of global or large-scale anthropogenic changes damaging the environment. In summary, following any of the logic threads presented or considering them in sum, environmental security should be a part of the American political agenda. All of these factors lead to environmental security now appearing as a part of the US national security policy.

D. The National Security Strategy and The National Military Strategy

Today, we at least recognize a broader sense for national security and inclusion of environmental issues as one component. Our National Security Strategy (NSS) for a New Century is the blueprint for all governmental actions associated with national defense and thus is the basis for strategic planning for the military. One of the '**important national interests**' identified in the December, 1999 NSS *is "protecting the global environment from severe harm*"[12]. Within the humanitarian and other interests, "*promoting sustainable development and environmental protection*[13]" is listed. Further, many of the human issues

[12] The White House, A National Security Strategy for a New Century, 1.
[13] Ibid, 2.

identified in the NSS have root causes in environmental problems. As an example, the problem of refugee flow is marked as an important national interest, though more and more, environmental degradation is a major push factor creating mass migration, and leads to the starvation, epidemic disease, and the civil unrest that make refugees a security concern. Overall, the NSS now recognizes that environmental issues are significant concerns in our national security and that they must be incorporated into our plan for preserving American security.

The NSS is the guide for all parts of the national government in mapping their activities in pursuit of peace and security for our country. Environmental security is one of several issues raised in the NSS requiring coordinated actions from many agencies and departments, including but not limited to the DOD. Presently, DOD, the US Environmental Protection Agency (EPA), the Department of Energy (DOE), and the Department of State (DOS) informally coordinate environmental security issues. Working groups and workshops meet irregularly to develop the relationships necessary to accomplish the NSS environmental requirements, but these efforts suffer from a lack of priority within the individual organizations and no overall national leader, or advocate. Within the DOD the environmental protection component of the NSS has been addressed under the title 'environmental security'. Offices have been established within the DOD and programs are organized under the Deputy Under Secretary of Defense for Environmental Security.

The NSS becomes the baseline guidance for all that will become our National Military Strategy (NMS). It then follows that the Chairman of the Joint Chiefs of Staff must consider the environmentally related requirements of the NSS as he develops and implements the National Military Strategy. In this context, the current National Military Strategy does incorporate environmental protection issues into the military strategy. In its analysis of the Strategic Environment the NMS states, "*environmental strains continue to cause instability and the potential for violence*[14]." Further, in describing transnational dangers, the NMS identifies that, " *massive refuge flow; and threats to the environment each have the potential to put U.S. interests at risk.*[15]" Overall, the threat analysis sections in both the NSS and NMS provide consistent approaches to defining the risks to national security posed by numerous environmental issues. However, continuing in the NMS to its strategic planning sections, the 'how' to address these issues are absent. Certainly the NMS is a 'big picture' strategic document and cannot cover all details for every security concern, but it is clear that "Shape, Respond, and Prepare Now" should include environmental actions to respond to its own threat analysis. As will be proposed in the analysis section (Chapter 4), 'Shape' is the most important aspect of environmental security planning.

Differences between the NSS and the NMS are expected and reflect that conceptually NSS is a document that includes the total responsibilities of the government to protect the national security of which as stated in the NMS, "*The military is a complementary element of national power that stands with the other instruments wielded by our government*[16]". Diplomacy through the Department of State, economic leverage applied by many parts of the government are just two examples of how other activities of the government can be brought to bear on security issues. In the context of environmental protection, certainly the actions of EPA from their view of environmental security contribute to meeting the environmental goals established in the NSS[17]. One encumbrance to accomplishing the national security

[14] Ibid. 8.
[15] Ibid. 9.
[16] Ibid. 5.
[17] USEPA. Environmental Security, (USEPA. Washington, Sep 1999).

strategy environmental objectives is the lack of a coordinating plan at the national government level. This paper addresses primarily the military department's responses, but before this can be accomplished there must be a division of labor above the DOD level. Many environmental security issues are not a military responsibility and others will require a coordinated effort of several agencies. However, a plan must be in place before a coordinated battle plan can be developed. DOD continues to provide leadership in coordinating with other agencies and at the same time must develop and implement those plans and activities necessary to meet their assigned responsibilities within the NSS. To address this absence of this national level planning document, the strategic analysis conducted in Chapter 4 will provide a first attempt to identify the military and non-military responsibilities within the environmental security issues being examined.

E. Risk Assessment

In the course of this paper it will become clear that our scientific ability to predict environmental consequences from anthropogenic induced change are somewhere behind our ability to predict the weather next week. Competent scientists can look at the same set of data and reach diametrically opposite predictions. A case in point is global warming, --- alias the greenhouse effect, alias --carbon dioxide pollution of the global environment. Later in the paper we will explain the concepts in detail, but for now accept this example to illustrate a one point. First, it is simple enough to deduce that adding carbon dioxide to the air is a bad thing, which will therefore produce specific consequences – i.e. the earth warms – the ice caps melt – and we create a water world. However, the interactions of the carbon cycle, other changes to the environment that are occurring concurrently, plus the natural systems regulating mechanisms make this an extremely complex system to interpret. So, if you look in the literature you still find fine scientists predicting warming, cooling, major climate changes, minor changes, and all points in between. As with nearly all issues we will examine, there are facts that we know with certainty, there is data collected over a relatively short duration from a geologic perspective, and there is the current body of science to analyze and interpret the facts. In total, these offer us ideas or alternative views of the future, each without a preciseness or certainty we desire.

This research cannot proceed in the ambivalence seen in the current body of knowledge describing the impacts of man's impact on the environment, but must make some fundamental assumptions concerning extent and magnitude of the impacts of anthropogenic induced change. Using the risk assessment model often employed to quantify consequences of environmental contamination events will provide a logical framework to conduct our analysis. In this process: total risk of an event is defined as:

$$\text{RISK} = \text{probability of the event occurring} \times \text{severity of the impact} \qquad (1\text{-}1)$$

An example should help to explain the concept. Each time you drive your car you are subjected to a risk of an accident, no matter how well you drive. The probability of an accident can be expressed in several ways, including: 1) there is a 1/10,000 chance of an accident each time you drive your car, or 2) on average, you will have an accident once for each 100,000 miles you drive. These numbers are based on data generated through accident reporting. For the second term in Equation 1-1, the severity of the accident must now be expressed in quantitative terms. One way of expressing the severity of the impact is--- for each person in car accident. 1 out of 100 people die. Your total risk then for dying in a car accident in this example is:

$$RISK = 1/\ 100{,}000 \times 1/100 = 1/10{,}000{,}000 \quad (1 - 2)$$

In words, you have a one in ten million chance of dying for each 100,000 miles you drive. In summary, risk is the chance of occurrence multiplied by the magnitude of the consequence.

The reason for this example was to demonstrate that under the uncertain conditions of predicting future consequences, a risk based approach provides a useful tool to evaluate environmental issues. and is particularly robust in comparing alternatives. Risk analysis suggests that either of two conditions can dictate that an environmental issue is important to national security. these being issues with a high probability of occurrence or those with consequences so dire that every possible alternative of avoidance or mitigation should be examined. Going back to my global warming example. we don't have a good estimate on the probability of occurrence. but we recognize that potential impacts are destabilizing on a worldwide basis. and therefore prudence necessitates its consideration under the criteria of the NSS. This is process that will be followed in identifying the limited number of environmental issues to be evaluated in this report.

F. Goals and Purpose

The goal of this work is to produce a document that both meets standards for good academic research, which is to advance the body of understanding in environmental security. and also passes the common sense or utility test. To many these two goals seem mutually exclusive, thus linking them in the purpose becomes a highly risky process. But as we just determined in our description of risk assessment, where the risks of failure are far outweighed by the opportunity to contribute in a positive way to our national security, take the risk. Early research into the subject of environmental security quickly revealed that the needs for study fell into two general categories. First, was the need for a primer on environmental issues and how they relate to national security. A recent finding from a plenary session of several agencies involved in environmental security studies listed an environmental security primer as an essential requirement to help further the cause of environmental security. From the military perspective, our leadership must understand the environmental security issues, from both a scientific and policy view. To maintain a military focus the target audience selected for this document is the geographic Commanders in Chiefs (CINCs) and their staffs. In military environmental security activities, CINCs have important roles to play, however they arrive at the position with vastly different levels of knowledge on the subject. This document, particularly Chapter 3, is intended to jump-start a commander's understanding of the subject. The second contribution that can be made in this project is to begin the strategic analysis process for the military. Following the risk model described above, issues can be analyzed on the basis of national, then military impacts. For those where actions within the National Military Strategy are appropriate, issues can be prioritized, and responses can be developed. The task of this strategic analysis will be to define specific environmental issues that threaten stability and peace. This definition begins with identifying the candidate issues and then assessing those that are relevant to military activities or have solutions within the defense component of the government.

This then brings us to the basis for the second question posed in the preface;

What is the military mission in environmental security and how should we be executing this mission?

As with everything that the military accomplishes. the key to success will be careful analysis and planning. Military planners and operators need support in defining issues. assessing potential concerns. and developing plans that best utilize the capabilities of the military. At the national level. the military response should fit into planning based on achieving the goals of the NSS. This research found no evidence of detailed environmental security planning. nor planning integration at the national level. Comments will be presented concerning needs in national level planning just to the extent required to develop the context for military activities as a complementary part. but this is not a primary focus of this research

G. Products of the Research

This study does not purport to be able to completely close the void by providing a final environmental security strategy. but it can make significant contributions toward planning and execution of this mission by providing the following:

1) A scientific summary of the major environmental issues to help educate our leadership on the concepts.

2) A summary level study of strategic options in military environmental security policy. This includes a threat assessment to identify the most critical issues and a global scale geographic analysis to highlight the regions of highest concern.

3) Finally, this research can propose missions for the military in support of the national environmental security strategy.

G. A Little Science

Many readers may not be familiar with some the scientific jargon and units of measure that will appear in this document. To assist in understanding the important issues and make the reading more comfortable. Appendix A provides a ready reference and sanity check for the terms of environmental measure. Normal practice of writing out each term at first use will be followed, but Appendix A offers more in describing selected terms appearing throughout this document. Appendix A also includes a list of all abbreviations utilized in this document.

Chapter 2

ENVIRONMENTAL SECURITY DEFINED

A. Background

In Chapter 1 you were introduced to Professor Brodie and his view of the misuse of jargon and also this author's opinion that **environmental security** is an often misused and regularly misunderstood lexicon of military culture today. The data to support this are clear, with 20+ definitions for environmental security readily available in just recent government publications, clearly there is no accepted definition or consistent understanding of the term environmental security within the United States government or specifically the Department of Defense. Environmental security seems to have evolved from the early work of Myers[1] and others who focused on environmental issues with the potential to impact international security or world peace and into a term applied to encompass any activity with the word environment associated with it. At the outset of this research it was believed that senior military leaders understood the definition of environmental security, but lacked an understanding of the underlying scientific basis for the environmental issues. As the research proceeded the discovery of more than 20 definitions convinced this researcher that the Department of Defense (DOD) lacks a general agreement on the definition of environmental security. Personally, the real proof of the existing confusion came from listening to the term environmental security being used by our senior DOD officials. At the most recent US Army senior environmental leadership conference the term was used frequently, but each time with a different

[1] Norman Myers, The Environmental Dimension to Security Issues, (The Environmentalist, 1986) 251-257.

contextual meaning[2]. For a three-star general integrally involved with the Army force structure, environmental security meant a force protection issue, keeping deployed forces safe from environmental hazards in their area of operation. Another senior officer used environmental security in reference to garrison environmental health and safety programs, in the context of compliance with state and federal regulations. Within the 20+ definitions found in the literature, both of these generals were correct, though it would be hard to ever be wrong over the range of definitions available today.

B. Existing Definitions of Environmental Security

A recent study sponsored by the Army Environmental Policy Institute devoted specifically to the defining environmental security documented the existing confusion[3], but was not able to resolve the definition problem. One option considered early in this study was to develop a new term specific to the environmental requirements of the National Security Strategy and National Military Strategy. This approach would decouple the important national security issues from the baggage of confusion now encumbering the term environmental security. This approach was rejected because common sense suggested we have enough jargon already and from a philosophical standpoint inventing a new term seems a poor approach to reducing the total confusion in the military jargon.

This project requires a definition for environmental security describing its goals and objectives. Presented below are several definitions extracted from a variety of

[2] King, W.C., Personal communication, US Army Senior Environmental Leadership Conference, (Washington, D.C. March 2000)
[3] Jerome Glenn and others, Defining Environmental Security: Implications for the U.S.Army, (AEPI 1998).

sources working in the field of environmental security. These definitions are presented to demonstrate the wide range of views of the term environmental security and to serve as a basis for defining environmental security for this project.

United States Environmental Protection Agency[4]

Environmental security is a process whereby solutions to environmental problems contribute to national security objectives.

An Academically Inspired Definition[5]

Environmental security is the proactive minimization of anthropogenic threats to the functional integrity of the biosphere and thus to its interdependent human component.

Army Environmental Policy Institute Study[6]

This report did not develop a specific definition, but defined the key elements of environmental security as:

1. Public safety from environmental dangers caused by natural or human processes due to ignorance, accident, mismanagement, or design.
2. Amelioration of natural resource scarcity.
3. Maintenance of a healthy environment.
4. Amelioration of environmental degradation.
5. Prevention of social disorder and conflict (promotion of social stability).

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[4] USEPA, Environmental Security, (USEPA, 160-F99-001, 1999), 1.
[5] A really interesting definition found without specific reference.
[6] Jerome Glenn and others, Defining Environmental Security: Implications for the U.S.Army, (AEPI 1998), 19.

The uncontested winner for a definition that says it all, thus meaning nothing, is the DOD official definition: DOD Directive Number 4715.1, Environmental Security[7]

"*Definitions: 2. Environmental Security. The environmental security program enhances readiness by institutionalizing the Department of Defense's environmental, safety, and occupational health awareness, making it an integral part of the Department's daily activities. Environmental security is comprised of restoration, compliance, conservation, pollution prevention, safety, occupational health. explosive safety, fire and emergency services, pest management, environmental security technology, and international activities which are explained, as follows:*

a. Restoration is identification, evaluation. containment, treatment, and/or removal of contamination so that it no longer poses a threat to public health and the environment.

b. Compliance is meeting applicable statutory, Executive order, and regulatory standards for all environmental security functions, including FGS or the Overseas Environmental Baseline Guidance Document. as appropriate.

c. Conservation is planned management. use, and protection: continued benefit for present and future generations; and prevention of exploitation. destruction. and/or neglect of natural and cultural resources.

d. Pollution prevention is source reduction as defined in 42 U.S.C. 13101-13109 (reference(nn)). and other practices that reduce or eliminate the creation of pollutants through increased efficiency in the use of raw materials. energy. water and other resources. or protection of natural resources by conservation.

e. Safety is a multifaceted program designed to prevent accidental loss of human and material resources. and protects the environment from the potentially damaging effects of DoD mishaps.

f. Occupational health protects personnel from health risks. and includes occupational medicine. illness and injury trend analysis. epidemiology. occupational health nursing, industrial hygiene. and radiological health.

g. Fire and emergency services enhance combat capability by preserving life and DoD property through fire suppression. fire prevention. fire protection engineering, and emergency responses.

h. Explosives safety protects personnel, property. and military equipment from unnecessary exposure to the hazards associated with DoD ammunition and explosives: and protects the environment from the potentially damaging effects of DoD ammunition and explosives.

i. Pest management is the prevention and control of disease vectors and pests that may adversely affect the DoD mission or military operations: the health and well-being of people; or structures, material. or property.

j. Environmental security technology consists of research, development, test and evaluation. and regulatory certification of innovative technologies responsive to user needs.

k. International environmental activities include bilateral or multilateral agreements, information exchanges, cooperative agreements, and specific actions;

[7] DOD, Environmental Security, (Directive Number 4715.1. Feb 1996).

consistent with the responsibilities identified in subsection E.3. above to bring DoD resources to bear on international military-related environmental matters or otherwise appropriate in support of national defense policy interests.

C. Project Definition of Environmental Security

> *Environmental security requires effective response to changing environmental conditions that have the potential to reduce peace and stability in the world. It is a process to assure accomplishment of the environmentally related actions specified in the National Security Strategy. Accomplishing our national environmental security goals mandates planning and execution of programs to prevent and mitigate anthropogenically induced adverse changes in the environment. Further, detailed planning is required to develop effective response mechanisms to minimize the impacts over the range of environmental disasters that could occur.*

This definition focuses on meeting the established goals of the NSS, which should be the basis for all U.S. security planning. Further, environmental security considerations within the DOD have their roots in the context of preventive defense strategy of former Sec of Defense William Perry[8].

The secondary effect underlying this definition purports that cooperation among nations and regions to solve environmental problems can help advance the goals of political stability, economic development, and peace. In the context of peace building, there are positive and negative aspects of the environmental security issues. Rightfully, the negatives dominating our interest include global climate change producing

[8] Gary Vest. DOD International Environmental Activities. (Federal Facilities Journal, Spring, 1997). 8.

catastrophic suffering, mass migrations searching for water and other scarce resources, and deforestation of irreplaceable tropical forests, just to highlight three. There are positives from a military sense. One of the existing good news elements of the current DOD environmental security program is the cooperative relationships being built with other nations on a foundation sharing environmental management. Many of the military exchanges with the countries emerging from the former Soviet bloc have begun with environmental topics. These opportunities can pay double for the DOD, building better military to military bridges while working directly on the important strategic environmental concerns. The task as this research now proceeds is to identify the important environmental scarcity and degradation issues and then find the best ways to employ the military in addressing these problems.

Chapter 3

ENVIRONMENTAL ISSUES AND THEIR IMPACTS ON NATIONAL SECURITY

A. Introduction

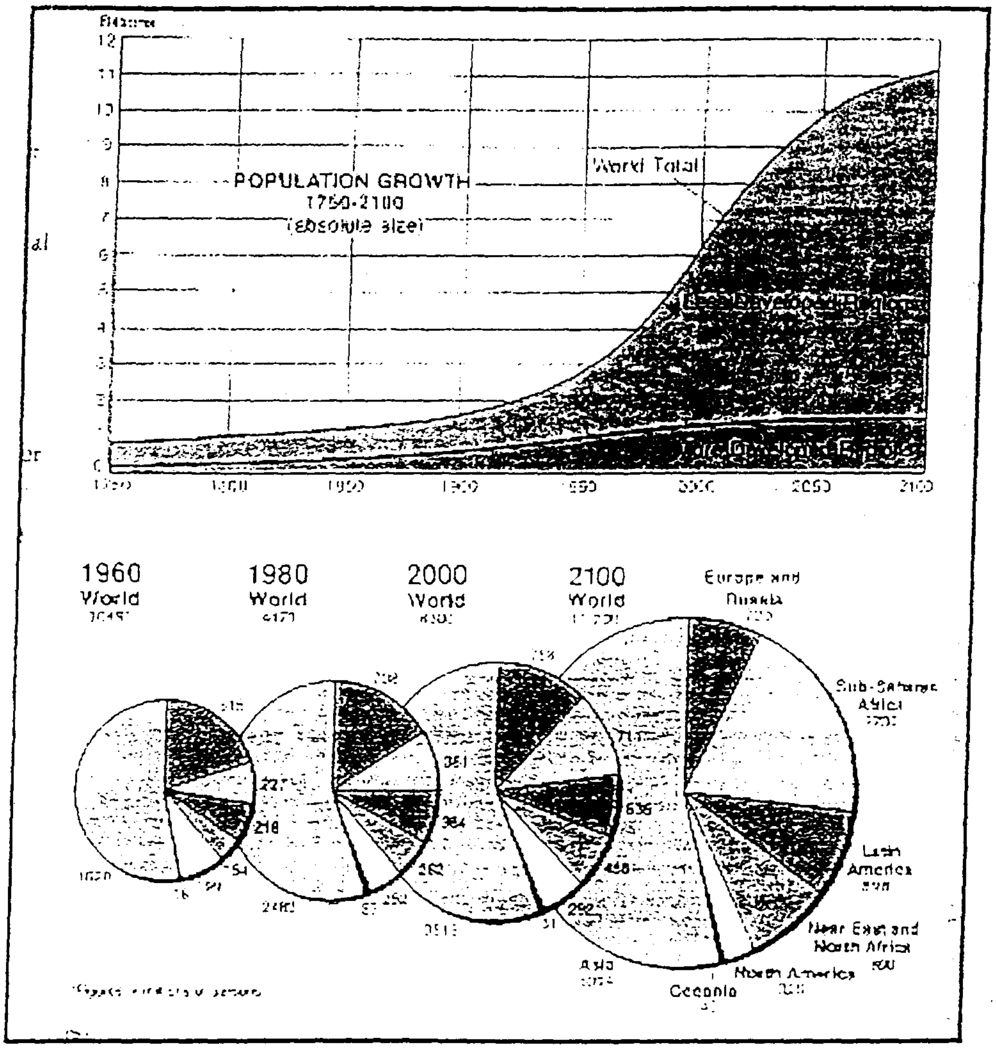
The goal of this chapter is to provide a fundamental understanding of critical environmental issues to all readers, which can then serve as a basis for a follow-on strategic analysis of the national security implications of these environmental stress factors. The " critical environmental issues" reflects two realities; 1) there are more environmental issues than can be covered effectively in this paper, and more fundamentally, 2) not all environmental issues have national security concerns. The concept of point 2) is simple enough, but actually deciding which environmental issues to include is fairly challenging. Sequential logical can perceive a threat in nearly all environmental issues, if not as primary effects, certainly with secondary or tertiary impacts influencing national security. As we see often in today's world, human suffering from floods, mud slides, drought, or any of a long list of calamities may cause the national command authority to select a military response as a component of our aid in these times of international crisis. Any use of military forces has national security implications, impacting the readiness of the troops by causing them to lose time to train for their war fighting mission, in diversion of resources from training, in wear and tear on military equipment (particularly air transportation assets), and numerous other spillover impacts.

The environmental issues selected for initial analysis are a compilation of environmental stresses identified in works published by the USEPA[1], AEPI[2], and a variety of authors

[1] U.S. Environmental Protection Agency, Environmental Security, 1999.

FIGURE 3-1

WORLD POPULATIONS, 1750 - 2100



Source: Arthur Gettis, et.al., Introduction to Geography (McGraw-Hill, NY, 1998) 142.

included in the bibliography. Note, population trends analysis are included here even though population is not generally thought of as an environmental issue, although there are strong arguments that it should be from the point of humans as part of the ecosystem. What is clear is that you cannot consider environmental security issues without concurrently examining population trends, particularly in a regional context. For example, consider the water scarcity issues in several regions of our country. Water scarcity evolves from pollution of existing sources, reduction of supplies, and increases in demand from either per capita demand increase or more people using at the same rate, but generally from all of these occurring concurrently. Analyzing water issues as we will do shortly must look at population trends as one of the variables in defining and predicting water demand. Therefore, we will begin this analysis by describing the population trends on a regional scale, which can then support on follow-on issues assessments. The issues for review are as follows:

- Population increase
  - Urbanization
- Global Climate Change
  - Carbon dioxide and greenhouse gases
  - Global warming
  - El Nino / La Nina
  - Ozone depletion in the stratosphere
- Land Use
  - Deforestation-- Biodiversity and the rainforests
  - Desertification
  - Hazardous wastes
- Water as a scarce resource
  - Oceans

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[2] Jerome Glenn and others, Defining Environmental Security: Implications for the U.S. Army, (Army Environmental Policy Institute, 1997).

B. Population

The increase in the human population of the earth over the last 250 years is depicted in Figure 3-1. including projections for the trends until the year 2100[3]. The impacts of rapidly increasing population are sufficiently evident that it no detailed explanation is needed, but one concept, carrying capacity, helps apply the fundamental issue of overpopulation to environmental security analysis. Ecology and human geography share the concept of **carrying capacity**, which defined in general terms, is the total population an area can support over an indefinite period of time[4]. The concept is readily reflected in livestock management practices where ranchers understand that a grazing area can sustain only a certain number of cattle or sheep per acre without long-term damage to the supporting vegetation. In the context of a specific region of the world carrying capacity is determined by the soils, the weather, abundance of water, and several other natural systems variables. This absolute value of **carrying capacity** can be influenced positively by technology with irrigation and fertilization, and it also is impacted by weather, drought for example, but over the long term only a finite number of animals can be supported without damaging the lands ability to sustain its natural state. In human terms this principle is equally valid. Technology can change the absolute value of human carrying capacity by allowing us to resource one region at the expense of another, but there are finite limits to the number of people any region

[3] Arthur Getis and others. Introduction to Geography. (Boston, McGraw-Hill, 1998), 192.
[4] Ibid, 217.

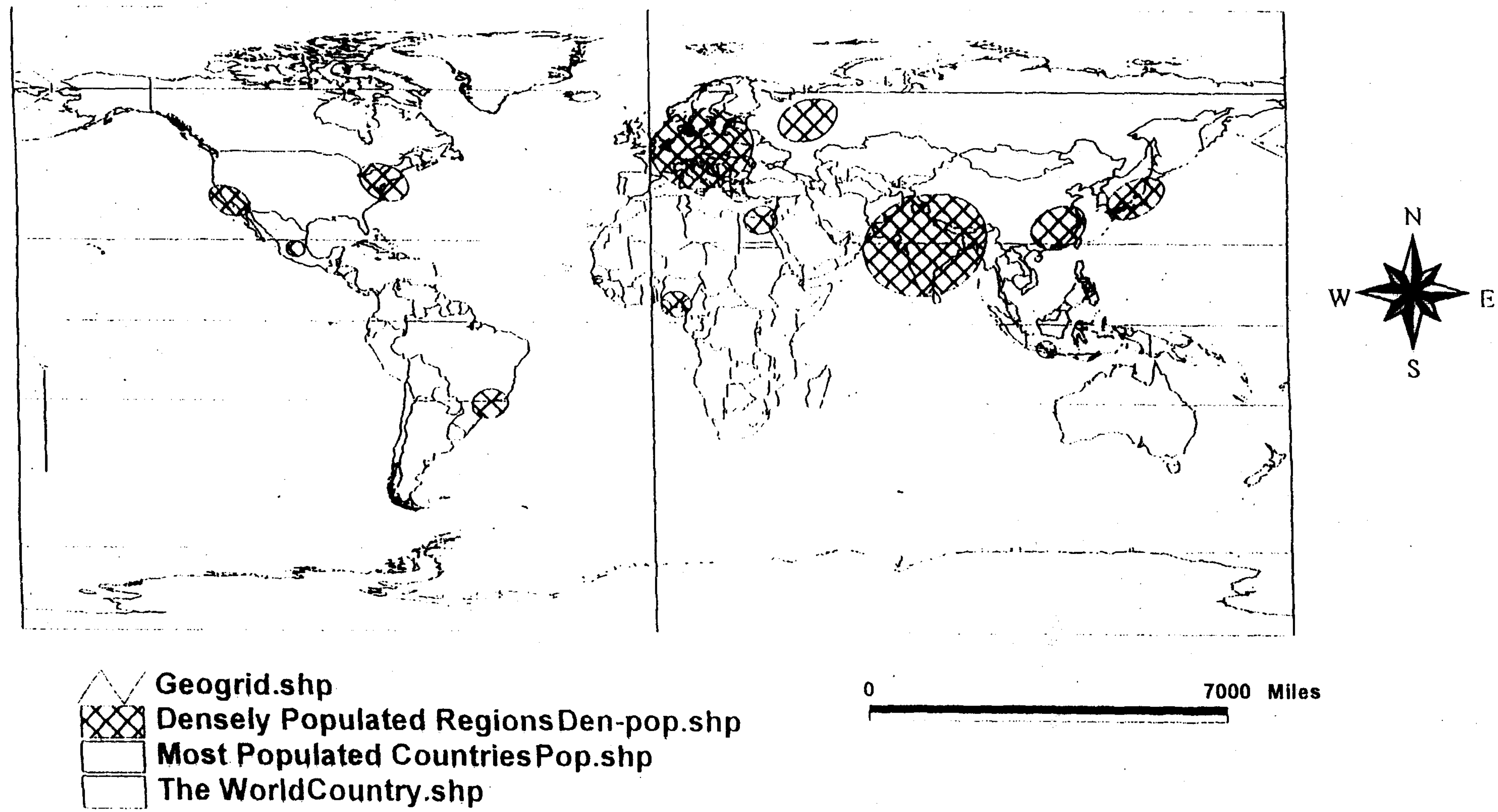
can support and therefore, the total population the entire world can support[5]. In reading some of the more academic philosophies of human activity there is a belief purported by some that technology can overcome the fundamentals of carrying capacity; to date this has not proven valid. The critical resources of water and energy[6] are renewable at finite rates, which humankind can impact only in minor percentages of total use. In the final analysis we remain one of the more fragile organisms on the planet, bound to a relatively constrained set of environmental conditions of temperature, oxygen, moisture, and available energy sources.

1. Issues of Population:

When one considers the concept of carrying capacity in the context of Figure 3 - 1 the abiding question is obvious, what is the total carrying capacity of the earth? Figure 3 - 1 predicts a steady state world population of between 11 and 12 billion people by 2100, nearly double the current world population. No one truly knows if the earth can sustain this number of people, but most scientists studying the issue are quite skeptical. If they are correct, two scenarios seem plausible. First, renewable resources are mined (withdrawn at a rate faster than they are replaced by the natural systems) until population far exceeds the carrying capacity. This initial population surge would then lead to a population die off to a new and often lower carrying capacity. The chaos in the world from this type of event suggests a highly insecure world for all nations. The second option is just a bit less threatening, but still bodes serious security concerns. Here, resource limitations come to bear on the rate of population growth so that the 11-12 billion predicted population is not reached. Famine, disease, increased infant mortality, and the reduction of life expectancy could come to bear as

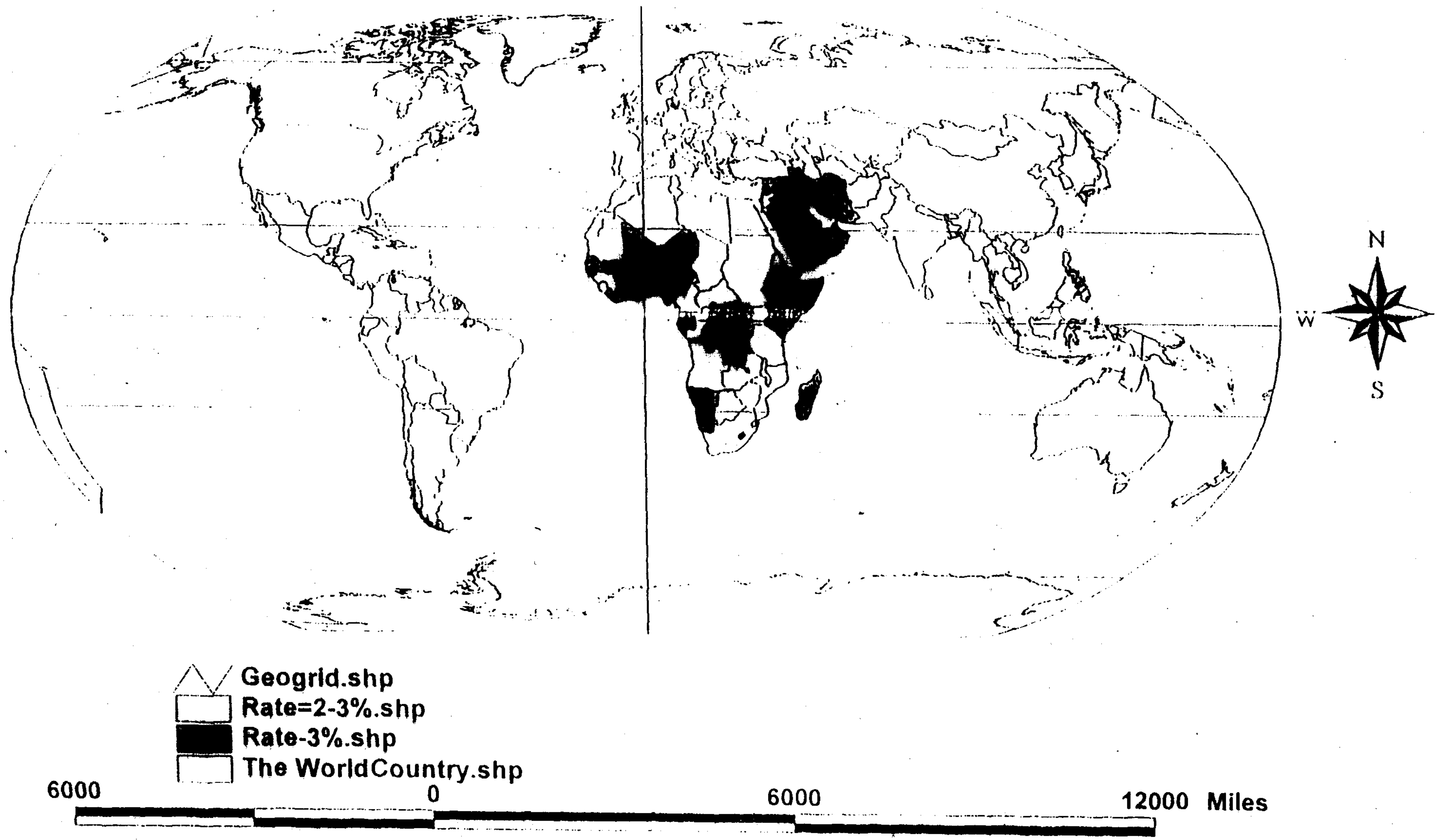
[5] Lester Brown and Hal Kane, Full House: Reassessing the Earth's Carrying Capacity, (Norton, 1994).

Figure 3 - 2
World's Most Populated Countries with High Density Regions



SOURCE: Rand McNally, Goode's World Atlas, 1995, page 25.

FIGURE 3 - 3
Population Natural Growth Rates



SOURCE: Rand McNally, Goode's World Atlas, `995, page 27.

regions reach limits in their ability to support the existing population. This scenario seems to be playing out in Africa where over the last ten years population growth predictions for sub-Saharan Africa have been reduced to reflect the impacts of disease, AIDS as an example, and other constraining factors.

The obvious follow-on question to our concern for the global picture and one that immediately relates to our environmental security analysis is, are there regions of the world that have already exceeded their carrying capacity or are in danger of doing so in the near term? To begin to address this question we need to examine existing and predicted population growth in a spatial context. Figure 3-2 is a representation of the most heavily populated regions of the world while Figure 3- 3 shows the countries with the highest natural growth rates. Neither of these figures in any way can be interpreted as defining regional carrying capacity, therefore do not directly answer the question at hand. Much more detailed analysis of specific regions will be required, but some summary judgements are possible. If we overlay areas of high population with areas of high growth rates, these regions are the most likely to yield problems in the future. A complete analysis of this type will be conducted in Chapter 4, but to illustrate the point we see that the west coast of Africa from Cote D'Ivoire to Nigeria, areas of Bangladesh and east India, and the Philippines are areas that meet these criteria. Later, as we collect our environmental issues data to locate areas with resource limitations, we will be able to overlay our population data to identify areas with large and growing populations that also have resource limitations. This begins to identify areas where the carrying capacity concept may come into play. This process of spatial representation and matching of data is the geographic information system process that

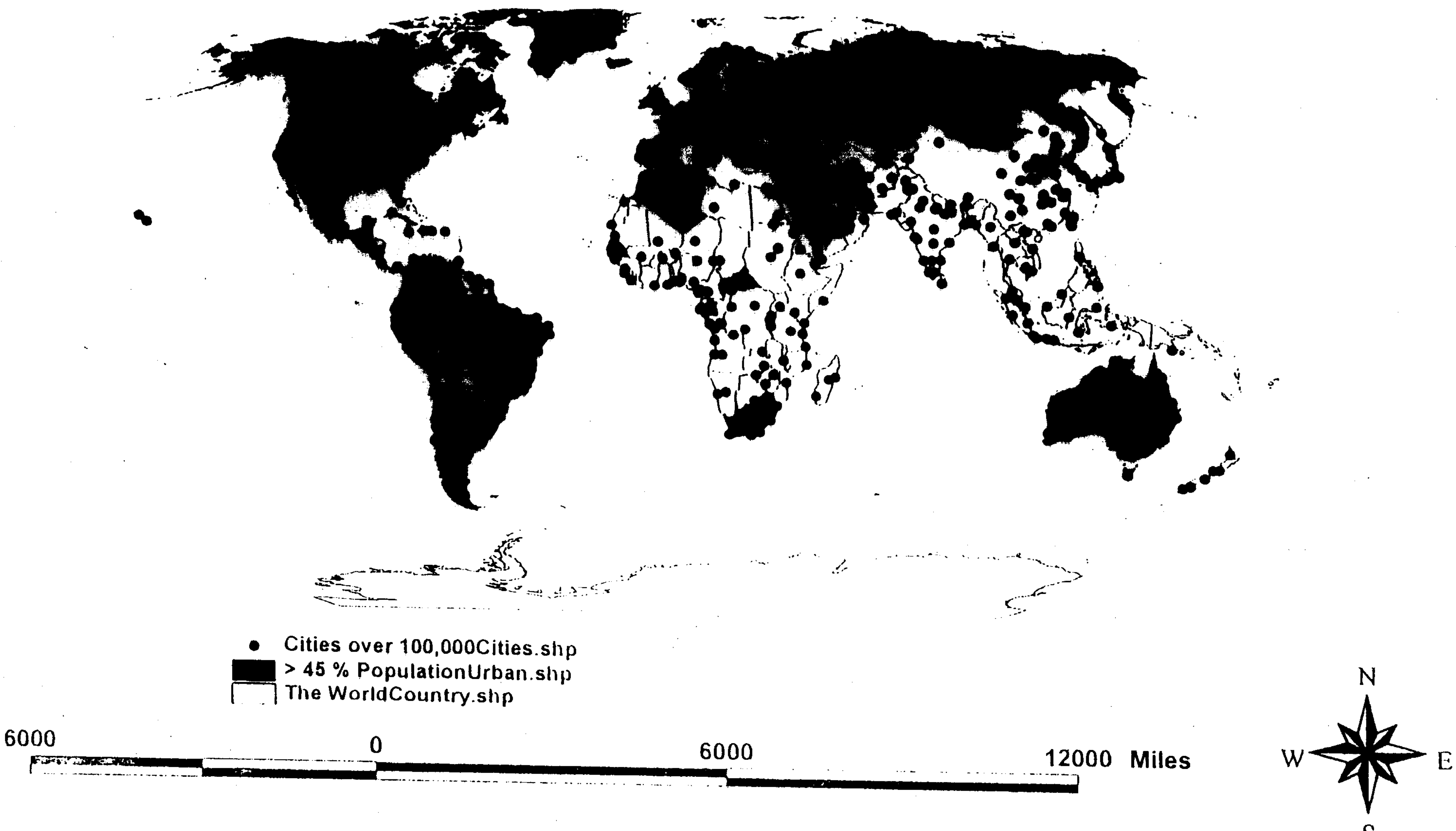
[6] Energy is used in the broadest sense in this context. This includes food, power used to support human activity such as heating, transportation, and many other energy consuming activities.

has evolved in the evolution of geospatial sciences and will be a primary tool for the analysis phase of this project. To the extent that the data is available, environmental issues will be quantified in the same spatial scale as seen in Figures 3-2 and 3-3, thus allowing for comparative analysis of regions. The power of this process will be discussed as the data is presented, but a caution must also be issued. All data of this report is at the macro-scale and cannot be used in too precise a way. This report intends to screen the world to help identify areas where theater commanders should focus for their more detailed analysis. Further, it proposes a methodology that is applicable at any scale where data is available.

A final complicating factor to the rigorous application of the principle of carrying capacity to human population is the trend in urbanization of the world population. Figure 3-4 shows the results of a trend through which the world population has transformed from 80 % rural in 1925 to one of 52 % rural today[7]. In some ways urbanization increases the efficiency of a society in energy and resource use, but at the same time it creates high demand areas in regions that may not be capable of sustaining the population. Consider the air pollution problems of major cities such as Los Angeles, Mexico City, or Santiago, Chile, or the water concerns for places such as Tucson, Phoenix, and numerous other towns in our Southwest. These are regions that have exceeded their carrying capacity of at least a part of their natural environment. Depending on the stage of economic development of the society, these type of issues have a greater or lesser impact on the population, but all represent the possibility of environmental induced strain.

[7] Edward Espenshade and others, Goode's World Atlas, (Rand McNally, 1995), 27.

FIGURE 3 - 4
Urbanized Countries and Large Cities



Source: Rand McNally, Goode's World Atlas, 1995.

2. Population Impacts.

Most of our analysis of the impact of population increase will be developed concurrent with discussion of the environmental factors, but we conclude this section by proposing that there are regions of the world that cannot, even under normal environmental conditions for that region, support the population that now exists. These regions lack one or more critical resources--- be it water, clean air, or energy (total: including food, power, and transportation energy), to provide for the basic requirements of the people. This is the belief for parts of North Africa today. In this situation people first mined the natural resources, consuming water, wood and other what should be renewable resources at a rate faster than it can be regenerated. The next response is to migrate to a region where they can better supported, but these opportunities are less and less in a world of 6 billion. In natural systems the final stage is the die-off phase. People, however, tend to respond more aggressively and where they have the means will try to take what they need from others. However it evolves, the population must fall back to the sustainable level. Often die-off is precipitated by some environmental event such as drought or flood, but war is also a possibility. The net impact is the population suffers a significant reduction over a short period of time. Obviously, each level of this hopeless cycle increases the insecurity in the region, until complete chaos exists. The term hopeless is employed in the sense that the basic principle of carrying capacity cannot be violated over the long term, thus it is hopeless to expect a region to long support more than its capacity for people. Worse, the first phase of mining of renewable resources actually reduces the natural carrying capacity of a land for some period, very long periods in fragile environments such as deserts and cold regions. To illustrate, this concept is well reflected in the process of crop rotation in agriculture. It is believed to be more efficient to overuse the land for a period, but then allow time for it to recover. However, it has been proven that without this recovery period the land produces less and less until it becomes unusable. As we will see in our discussion of desertification, people can do this to the entire ecosystem of an area.

Many authors continue to suggest that it is the resource side of the problem that must be addressed. Paul Simon's excellent book on water, **Tapped Out—the Coming World Crisis in Water and What We Can Do About It**[8], takes this general approach, fix the water problems and we can avoid the crisis. His concern with water and his solutions are all valid, but the underlying principle of carrying capacity cannot be violated. In the water context, the climate provides a watershed only a fixed amount of water. There is a minimum amount of water required per person per day for survival. The equation then becomes straightforward:

$$\frac{\text{Gallons of water available per year}}{\text{Gallons per person per year}} = \text{Human carrying capacity}$$

Conservation and other management tools can change the values in both the numerator and denominator, but cannot change the form of the analysis which calculates that only a certain number of people can be sustained in a region, based on its natural environmental setting.

C. Global Climate Change

1. The Science.

Today, assessing how man's activities are affecting the global climate is the most contentious issue in environmental security analysis. Our environmental security analysis begins with this issue because of the high risk of the consequences of climate change. The

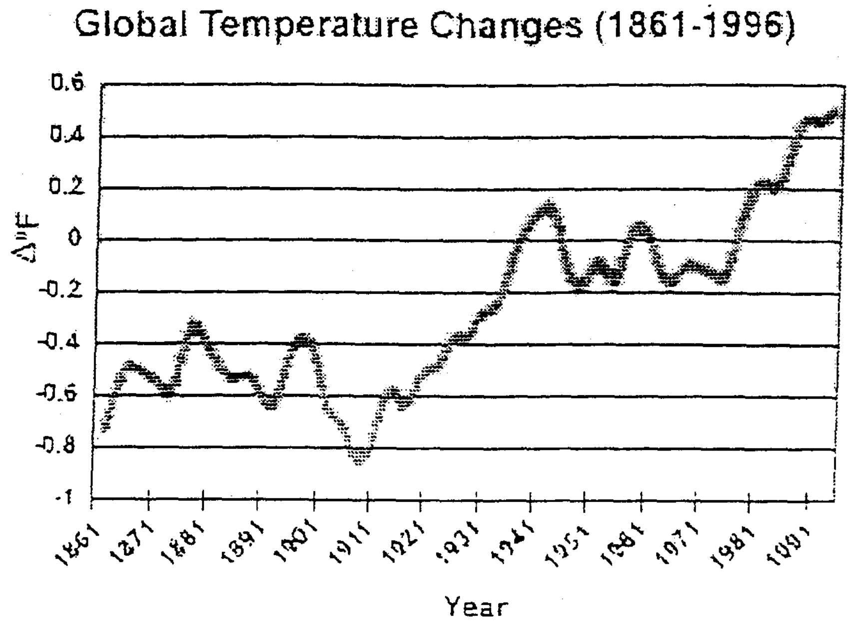
[8] Paul Simon, Tapped Out (Welcome Rain Pub., 1998).

discussion that follows documents the considerable existing uncertainty in the area of predicting future global climate change, but based on considerable the anthropogenically produced changes to the atmosphere, there is a sufficiently high probability of occurrence that the risks must be seriously considered. Most authors writing on this subject will immediately describe the issue as global warming, through their discussions admit a great deal of uncertainty exists in the analysis. Understanding global climate change is technically complex because of the many dependent variables in the defining equation and because of the natural variability of weather even without anthropogenic induced change. Breaking the impasse on the science of global climate change has seen considerable international cooperation, and in a sense can be considered as progress in security because of the many fruitful and cooperative discussions that have ensued. In 1988 the Intergovernmental Panel on Climate Change (IPCC) was formed. Over time the IPCC has produced several significant studies on this subject and been a vehicle to build consensus and reduce uncertainty. The IPCC results will be the basis for discussion at several points in this review and analysis, particularly in areas where wide diversity of opinion exists.

Most reputable scientists now believe that global climate change in the form of global warming caused by anthropogenic activity will occur. This will be produced by a series of interwoven phenomenon including but not limited to deforestation, burning of fossil fuels, industrial pollution, and urbanization. Assessing each of these factors independently in a static model is well within our scientific capability today, but is not reality. Each activity dependently occurs at different rates and concurrent with the natural variability in weather and climate. To illustrate where we are in our understanding take for example Figure 3-5, showing changes in world temperature over the past 135 years, the period for which we have measured data. Many look at these data and conclude that global warming is an acute issue brought on by man's abuse of his environment[9]. However, others point out that this change over such a minute period in the history of the earth is well within the statistical bounds of natural fluctuations[10]. Logically, what we see in Figure 3 - 5 must be both, the forced changes caused by man's inputs imbedded in the natural variability for that period; we unfortunately possess an insufficient understanding to separate the two components at this time. To understand global climate change this study begins by presenting the known factors in the equation, primarily: the greenhouse effect, the carbon cycle, and the increase in greenhouse gases produced by man's activities. With these as a basis we can build on the known science to more competently examine the feasible range of measured changes in our environment and then applies these to analyze possible human impacts.

[9] Rodney White; North, South and the Environmental Crisis (University of Toronto. 1993) 39.
[10] Horel and Geisler; Global Environmental Change. (John Wiley. 1997) 9.

FIGURE 3 - 5



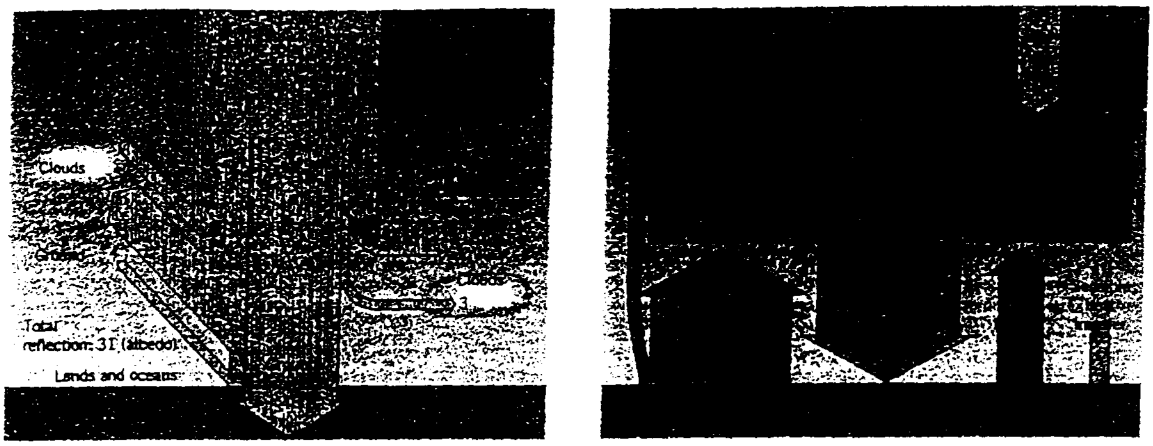
Source: IPCC (1995), updated.

The **Greenhouse Effect** is a term applied to describe the natural process by which the earth's atmosphere converts the sun's light energy into heat to warm the surface of the earth and make our planet inhabitable for all living organisms. It inherited this name because the process occurring in the earth's atmosphere is not unlike the way a greenhouse functions, naturally collecting and retaining the sun's energy to help its plants grow. First we need to discard a common error, the greenhouse effect is not the **BAD** process that causes global warming, though many authors misuse the term as such. It is an essential function of our ecosystem without which we could not habitat the earth.

Figure 3-6 is a simple model of the heating of the earth's surface by the sun. The sun's energy arrives at the top of the atmosphere as visible or short wavelength radiation, with most energy in the range of 0.3 to 0.7 micrometers. Each component (gases and particles) of the atmosphere has as a basic chemical property, how it interacts with electromagnetic energy that strikes it; the basic options are to reflect, absorb, or transmit (pass through) the energy. For example, oxygen which makes up just over 20 percent by weight of our atmosphere absorbs most light below 0.3 micrometers wavelength and is transparent to all longer wavelength energy. Nitrogen (80 percent of air) is transparent to all visible (short wave length) and heat radiation (long wavelength or infrared). Studying Figure 3-6, we see that a small percent of light is reflected by clouds, the ground, and the air; a small amount is absorbed by the atmosphere; but about half of the sun's light energy is absorbed by the ground. The light directly reflected by the ground does not change wavelengths therefore it will travel back into space because it is still transparent to the atmospheric gases. The unreflected energy reaching the surface is either absorbed at the surface, or is captured for use by the photosynthetic plants. The adsorption of energy by soil, rocks, and other materials

FIGURE 3 - 6

GLOBAL ENERGY BALANCE



Source: Alan Strahler and Strahler. Introducing Physical Geography. (Wiley. NY. 1998) 43.

warms the earth's surface. Since all warm bodies emit heat energy (see the right side of Figure 3-6,page 3-17) as longer wavelengths radiation (4-20 micrometers), the earth's surface becomes a source for infrared radiation. This long wavelength energy is transparent to oxygen and nitrogen, but is absorbed at different rates by several of the minor constituents of the atmosphere, both naturally occurring and anthropogenically generated substances. Gases that have the ability to absorb thermal wavelength energy have been defined as the **greenhouse gases**. Table 3-1 lists the greenhouse gases, their current atmospheric concentrations, their relative adsorptive capacities, and other important properties that will further our understanding of the greenhouse effect.

TABLE 3-1

Properties of Greenhouse Gases

Chemical	Preindustrial Atmospheric Concentration	Concentration In 1994	Adsorption wavelengths in the thermal range (micrometers)	Residence Time in the Atmosphere (years)	Strength of Adsorption Relative to Carbon Dioxide
Carbon Dioxide, CO_2	280 ppm	360 ppm	>10	3	1
Methane, CH_4	0.8 ppm	1.7 ppm	3 & 7	10	20
Freon, CFC-11&12	0	0.76 ppb	8 – 12	100	12,000
Nitrous Oxide, N_2O	0.288 ppb	0.31	8	150	200
Water, H_2O	Varies	Varies	3, 6, & 11	-	-

Notes: ppm = parts per million in volume to volume ratio; ppb = parts per billion by volume

Sources: Compiled from Noel de Nevers, Air Pollution Control Engineering, (McGraw-Hill, Boston, 2000) 523; Horel and Geisler, Global Environmental Change, (John Wiley, 1997), 98; and John Houghton: Global Warming, the Complete Briefing (Lion Publ., England, 1994) 22.

The greenhouse effect is then the warming of the atmosphere close to the ground by certain gases adsorbing heat radiated from the surface materials. Since, the amount of energy input by the sun is relatively constant from year to year, the temperature of the earth's atmosphere is regulated by the concentration of the greenhouse gases listed in Table 3-1.

Now each of these gases enters and leaves the atmosphere at rate determined by both natural cycles and inputs from human activity. Increases in the quantity of these gases present in the atmosphere disturb the balance and could influence atmospheric temperatures. Many very knowledgeable scientists conclude that the growth in greenhouse gases, particularly carbon dioxide, is causing an **Enhanced Greenhouse Effect** and this is the cause of the global warming reflected in Figure 3-5[11]. At this point we will examine the greenhouse gases on an individual basis to better interpret both their fate and impact in the environment, beginning with the least impacting and working to our major concern, carbon dioxide.

Nitrous oxide (yes, also known as laughing gas) is relevantly minor component of the environment and one that shows only small growth over the period shown in Table 3-1. There are both natural and manmade sources for nitrous oxide including natural biological processes, chemical manufacturing, and motor vehicles. The rate of production from all of these sources is not large enough to suggest large changes in the concentration in the future. Nitrous oxide is a gas that persists in the environment and is a strong adsorber, therefore any new major sources would be of concern, but again without significant changes in concentration nitrous oxide is not expected to further impact the global climate.

Freon is a common name for the most important forms of a class of chemicals more precisely described as chlorinated fluorocarbons (CFCs). CFCs are a class of manmade chemicals used in the past as a carrier gas for aerosol spray cans and more importantly as the gas used to produce the cooling reaction in refrigeration compressors. We will be much more interested in CFCs when we examine the problem of the hole in the ozone layer, but

[11] John Houghton; Global Warming, the Complete Briefing (Lion Publ., England, 1994).

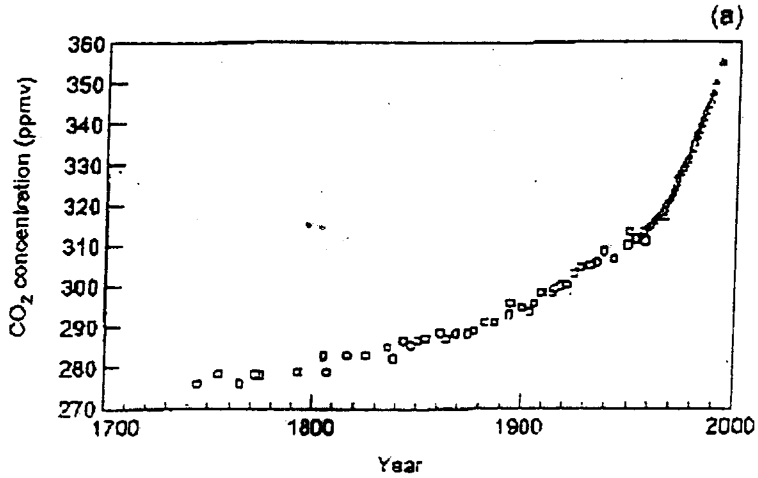
CFCs are also greenhouse gases because they adsorb thermal energy. Table 3-1 shows that CFCs are extremely adsorptive and highly persistent, thus at even small concentrations can contribute to the enhanced greenhouse effect. DeNevers estimates that 24 % of the manmade enhanced greenhouse effect is the result of CFCs[12]. If their concentration had continued to increase, they would have been of a major concern. Later in the chapter we will hear a good news story of a worldwide effort to eliminate this problem. The bad news of CFCs as a greenhouse gas is that even though we are reducing the concentration of CFCs in the atmosphere, an atmospheric residence time of 100 years is going to make recovery very slow.

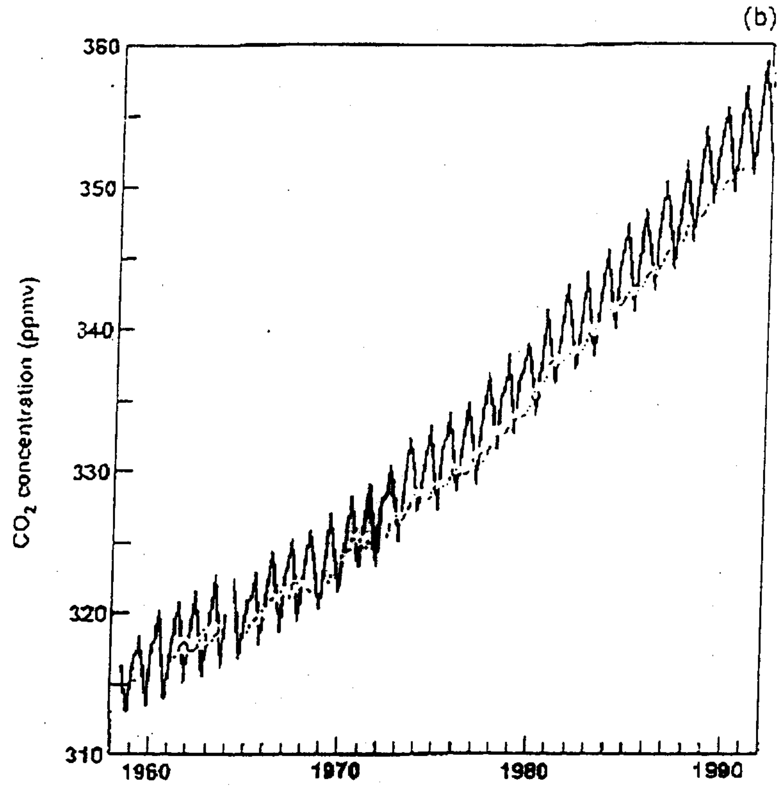
Methane is a naturally occurring gas that is also a by-product of many industrial processes and is the major component of the fuel "natural gas". Biochemical reactions that proceed in the absence of oxygen produce methane (swamp gas) as a by-product. Wetlands and paddy agriculture are the major sources of methane, followed by sources from the livestock production industry. Because methane is 20 times stronger than CO_2 in its greenhouse impact, is increasing, and has sources that are crosslinked to population, methane is a concern in the enhanced greenhouse effect.

Carbon dioxide (CO_2) concentration in the atmosphere is the big issue for the anthropogenic sources of the enhanced greenhouse effect. There is complete certainty that carbon dioxide is increasing in the air and that burning of fossil fuels is the cause. Figure 3-7 shows the trend in carbon dioxide concentration over the past 300 years with an expanded view since 1960. One perfunctory suggestion, notice the striking similarity in shape between Figure 3-5 and Figure 3-7? A mass balance of the total carbon in the environment as depicted in Figure 3-8 shows that fossil fuel burning and deforestation (details of

[12] Noel de Nevers, Air Pollution Control Engineering, (McGraw-Hill, Boston, 2000), 517.

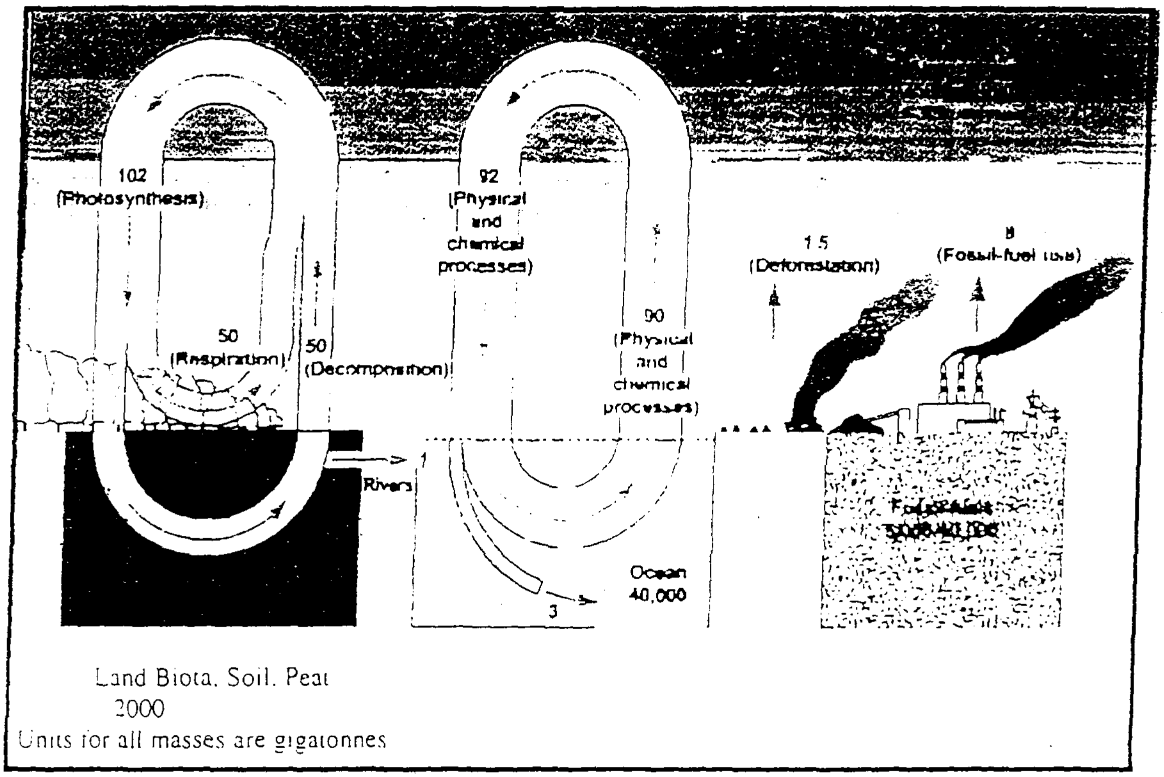
FIGURE 3 – 7
Carbon Dioxide Concentrations
a) 1700 – 1990s
b) 1960 to 1994 as measured at Mauna Loa Hawaii





Source: John Houghton. Global Warming (Lion. Oxford. England. 1994) 31.

FIGURE 3 – 8
THE CARBON CYCLE
1990 data



Source: John Houghton. Global Warming (Lion. Oxford. England. 1994) 30.

deforestation will be discussed later in this chapter) are adding CO_2 to the air faster than the natural systems can remove it, with a net increase of 3.5 gigatonnes per year.

A misconception in global warming brought on by some misunderstood science in the news media is that carbon dioxide is produced because of improper burning of fossil fuels. CO_2 is the clean by-product of the complete combustion of all fossil fuels and is not created by improper burning. Chemically,

Coal/petroleum/natural gas/methane + oxygen → carbon dioxide + water

Poor combustion processes produce carbon monoxide (CO) which is an air pollutant because of its deleterious health impacts, death being the most acute. The only method to reduce CO_2 production in burning coal, gasoline, or natural gas is to burn less fuel.

The fate of the carbon dioxide in the air is described as a part of the carbon cycle illustrated in Figure 3-8, a complex—dynamic system of chemical and biological processes. First, recognize there is a natural or good concentration of CO_2 in the air that is essential for the photosynthetic reactions in green plants. On land, photosynthesis captures CO_2, storing carbon in biomass and releasing oxygen back to the environment. This carbon can be released back to the atmosphere by natural decomposition or human activities. The reactions in the ocean are more complex because both chemical and biological processes come into play in transporting CO_2 from the air to the water, through biological processing, and finally to either return to the air or cause sink into the ocean where it is retained for long period.

One of the uncertainties in global warming is understanding how the theory of chemical reaction kinetics will come into play. We know that for all chemical and biological reactions, an increase in one of the inputs (reactants) drives increases in the rate at which reactions occur and the quantity of products produced. This leads to a hypothesis that an increase in CO_2 in the air can/will cause an increase in uptake rate of CO_2 and thereby compensate for or moderate the rate of increase in CO_2 in the atmosphere. However you evaluate the science of this theory, studying Figure 3-7 shows that this regulation has not occurred or is not large enough to counter-balance the large CO_2 inputs we see today. Houghton and others provide excellent discussions of the many different scenarios to predict carbon dioxide concentrations in the year 2100[13]. In all of these the main controlling factor is not the science, but the rate of fossil fuel burning. At best they present options where CO_2 levels off just over 400 parts per million (ppm) and the direst estimate has CO_2 exceeding 700 ppm by 2100. We have now reached our first major uncertainty in understanding how carbon dioxide will impact the global climate based on manmade and natural processes --- what will be the concentration of CO_2 in the air in the future?

Summarizing, Table 3-2 presents the release rates for greenhouse gases (GHGs) as self-reported by the major producers in the world.[14] The United States produces 25 % of the world's carbon releases and our burning of carbon fuels continues to increase over time. Without a paradigm shift in use patterns, into predictable future there will continue to be a growth in the greenhouse gases mainly in CO_2 production.

2. Impacts of Global Climate Change

We have alluded to the fact that the great uncertainty today challenging scientist's

[13] John Houghton; Global Warming, the Complete Briefing, (Lion Publ., England. 1994), 37.

[14] EPA. www.epa.gov/globalwarming/emissions/international/inventories.html. April 2000.

Table 3-2

Aggregate Greenhouse Gas Emissions,
Excluding Land-Use Change and Forestry
(MMTCE)

Country	1990	1991	1992	1993	1994	1995	1996
Australia	113.4	113.4	114.5	114.5	115.6	118.8	121.6
Austria	21.1	22.3	20.7	20.4	20.4	21.5	21.9
Belgium	37.9	39.0	38.3	37.9	39.4	39.6	41.4
Canada	163.1	161.5	164.7	168.0	172.9	178.2	183.1
Czech Republic	52.4	48.2	44.5	43.0	40.9	41.2	41.9
Denmark	19.5	22.5	21.1	21.5	22.5	21.5	25.3
France	151.9	158.0	155.0	147.4	147.4	149.4	153.3
Germany	329.8	316.6	303.4	300.1	296.8	292.8	297.6
Greece	28.7	28.7	29.0	29.3	29.8	30.6	31.3
Ireland	15.5	15.4	15.5	15.5	16.0	16.2	16.3
Japan	333.2	339.9	346.5	343.2	363.2	368.8	-
Latvia	9.7	8.0	7.0	6.0	5.3	5.2	4.9
Monaco	0.03	0.04	0.04	0.04	0.04	0.04	0.04
Netherlands	59.2	61.0	60.4	61.0	61.6	63.9	66.3
New Zealand	19.8	19.8	19.9	19.9	19.8	19.8	20.4
Norway	15.0	14.4	14.0	14.6	15.2	15.3	16.1
Slovakia	19.8	17.4	16.0	15.2	14.2	14.8	15.0
Sweden	17.8	17.6	17.9	17.9	18.5	18.3	19.8
Switzerland	14.7	15.1	14.8	14.4	14.2	14.4	14.6
United Kingdom	206.7	206.7	200.5	194.3	192.2	189.6	195.5
United States*	1,632.1	1,620.0	1,645.2	1,675.0	1,713.2	1,733.9	1,790.5

- Data not available
* Emissions data taken from the latest "Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-1997.

Source: www.epa.gov/global/warming/emissions/international/inventories.html, April 2000.

understanding of the Enhanced Greenhouse Effect is defining the relationship between changes in GHGs concentrationsin the air and changes in the climate. A consensus of scientists today believe that increases in CO_2 will have a direct impact on temperature. simply stated, increases in CO_2 will produce increases in global temperatures. Comparing

Figure 3-7 with Figure 3-5 seems to indicate a very strong correlation between the two variables, but this is much too simplistic an approach to be valid. Predicting temperature change within the dynamics of the greenhouse gases and the natural climate change is the primary source of uncertainty in the global warming debate. Complex computer models have been developed and are being continually updated, but each has its strengths and weaknesses. A wide range of predictions exists, but they generally fall in the 0.5 - 5.0 °C range. Without the details of the many strengths and weaknesses in our ability to model our climate, we have reached a second major level of uncertainty, knowing how much will the temperature change if the greenhouse gases increase.

To proceed further with our analysis of estimates of impacts from the enhanced greenhouse effect, we must choose a temperature prediction from among the range available. Because they represent the best consensus of scientists worldwide and have received the most scrutiny, we will use both the range of temperature rise caused by the enhanced greenhouse effect and continued increases in GHG emissions worldwide projected by the IPCC and supported by USEPA, or 1 to 3.5 °C temperature increase by 2100[15]. Here we introduce another level of uncertainty into the global warming debate, and arguably the one of great contention in the scientific community. Again, interactions between systems, actions and counteractions of the carbon cycle, and other processes make it complex for us to understand how atmospheric warming will change the earth. Based on our understanding of climate and weather today, a rise in temperatures worldwide and changes in temperature distribution spatially and temporally will change weather and climate over the earth. We know weather is primarily driven by the sun's energy being unequally distributed over space

[15] EPA, www.epa.gov/globalwarming/publications/reference/ipcc/summary/page4.html, April 2000.

and time. Higher temperature will produce more evaporation from the oceans and this will increase rains, somewhere. Higher temperatures over land will increase evaporation of soil moisture, increase dry soil temperatures, and melt ice. All of these factors will combine to change the weather patterns of a particular region, in both frequency and intensity of events.

Sea level rise has been the issue that seems to have captured the most attention, but there are many other equally important possibilities that must be assessed, particularly to apply in our study of environmental security. Based on scientific analysis to date, we believe the range of sea level rise will be between -1 and +6 meters, not a particularly informative range to use in assessing impacts. We do have a general certainty of the factors that enter into this calculation. First, we know that warmer water occupies a larger volume than cold water, so as ocean surface temperatures warm because of contact with the warmer air, the depth of the ocean will increase. The more difficult factor to calculate is the depth change attributable to warmer air temperatures occurring in regions with snow and ice cover. Whether and how much ice will melt under different warming predictions yields the wide swing in the estimates sea rise estimates. Using the IPCC warming estimates as a basis for temperature rise[16], Houghton predicts a 50-centimeter (1.65 feet) sea level rise by the year 2100. The most detailed statistical analysis of sea rise predicts 35 cm rise by 2100 as the most likely result with a 10 percent chance of sea rise reaching 65 centimeters, and a 1 percent chance of a 1 meter rise[17]. This rise coupled with natural land subsidence in some lowland regions could have large impacts in several critical areas of the world. Bangladesh

[16] IPCC, Climate Change 1992, the Supplemental Report to the IPCC Scientific Assessment.
[17] James Titus and Vijay Narayanan, The Probability of Sea Level Rise, (EPA, Washington, D.C., 1995).

FIGURE 3 - 9

HOUGTHON'S PREDICTIONS OF CLIMATE CHANGE

Estimates of regional changes by 2030[8]

In the IPCC 1990 report, estimates were given for climate changes by the year 2030 under a business-as-usual scenario of greenhouse gas emissions, for the five regions shown in the map of Fig. 6.4. These regional estimates can be summarized as follows:

Central North America
Warming varies from 2 to 4°C in winter and 2 to 3°C in summer. Precipitation increases up to 15 per cent in winter whereas there are decreases of 5 to 10 per cent in summer. Soil moisture decreases in summer by 15 to 20 per cent.

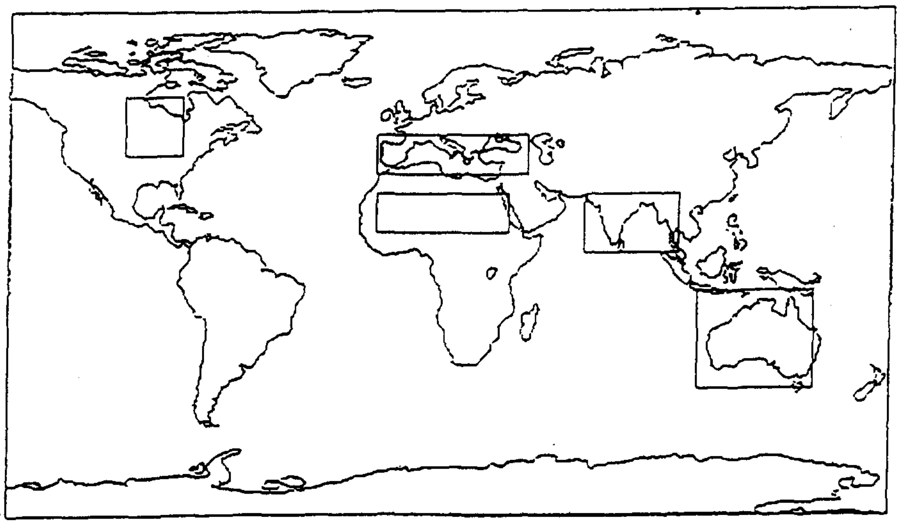
Southern Asia
Warming varies from 1 to 2°C throughout the year. Precipitation changes little in winter, but in the summer monsoon increases by 5 to 15 per cent[9]. Summer soil moisture increases by 5 to 10 per cent.

Sahel region of Africa
Warming ranges from 1 to 3°C. Area mean rainfall increases and area mean soil moisture decreases marginally in summer. However, within the region, there are areas of both increase and decrease in rainfall and soil moisture.

Southern Europe
Warming is about 2°C in winter and varies from 2 to 3°C in summer. There is some indication of increased precipitation in winter, but summer precipitation decreases by 5 to 15 per cent, and summer soil moisture by 15 to 25 per cent.

Australia
The warming ranges from 1 to 2°C in summer and is about 2°C in winter. Summer precipitation increases by about 10 per cent, but the models do not produce any consistent estimates of the changes in soil moisture. The area averages hide large variations at the sub-continental level.

FIG. 6.4 Map of regions chosen for estimates of regional climate change.



Source: John Houghton. Global Warming (Lion, Oxford, England. 1994) 84. After the IPCC, 1990.

a. Will the predicted increases in rain in the winter recharge the aquifer sufficiently so that additional water can used in irrigation in the summer over an indefinite period and possibly increase production through a longer growing season,

b. or, will the needed additional summer withdrawals further deplete the aquifer and deplete the water supplies throughout the aquifer including drying up much of southern Texas?

Our scientific understanding does not allow us to definitively answer these questions today and this is for one of the most studied hydrologic systems in the world. Clearly in the country in the world most capable of mitigating them, the impacts on economics, quality of life, and other secondary impacts could be immense.

On a worldwide basis Table 3- 3 is a synthesis of predicted impacts from regional climate change based on IPCC Global Climate Change studies as summarized by USEPA. The strategic significance of these data will be analyzed in the next chapter, but here we can examine the trends seen. Regions such as tropical Asia and Africa relying on single crop agriculture and subsistence farming are particularly vulnerable to changes in weather patterns. Vector and waterborne disease is expected to rise in the developing regions of the world and areas where more extremes in weather will increase the frequency of weather driven disasters. Many of the environmental issues we will discuss later in this

TABLE 3-3

Regional Impacts of Enhanced Greenhouse Effects on Climate

IMPACTS	North America	Tropical Asia	Temperate Asia	Arid Western Asia	Europe	Africa	Australasia
Geographic Area	Canada, US, and Arctic Circle	India, Pakistan, Bangladesh, Vietnam, Malaysia, and inclusive counties	Japan, Koreas, Mongolia, most of China, and Russian Siberia	Turkey in the west to Kazakstan in the east	West of Ural Mountains	The continent	Australia, New Zealand, and islands
Ecosystem	Shifts in location of forests and croplands; change of vegetation types; loss of waterfowl habitat	Changes in distribution of rainforest; drying of wetlands.	Reduction in the boreal forests, expanded grasslands, decrease in the tundra zone	No large changes.	Mostly disturbed environment now. Alter wetlands through lower ground water levels	Desertification in north, loss of forests in SubSahara; deterioration of land cover. Major impacts expected throughout.	Alterations of soils and vegetation could be large.
Hydrology and Water Resources	Increased Spring and Winter runoff; decreased rain and soil moisture in summer.	Glaciers recede in Himalayas; more seasonal impacts.	Net decrease in water supply, glacier melt; North China water supplies vulnerable	Continued water shortages in the region	Increased precipitation in high latitudes and reduced in lower; loss of glaciers with water storage processes.	Reduction in supplies in Sahel and southern Africa. Acute concern in many already water scarce countries of the region.	Reduce water could be critical in drought prone areas; loss of snow and glaciers in New Zealand; flooding.
Food and Fiber Production	Small changes, plus and minus inputs	Vulnerable to natural disasters. Changes in production and yield very difficult to predict, but crops are sensitive to temperature and moisture.	Not agreement in predicted change,	No large net change	Shift of growing seasons and patterns. Possible increased production.	Water shortages could be acute to farming in the North. Winter wheat growing in north hurt. Could have moderate increases in the south.	Early increased production predicted, but uncertain long-term impacts.
Human settlements	Changes in energy use; increased natural hazards.	Inundation of lowland cities,; salt water intrusion into water supplies in lowlands	Land subsidence in lowlands, slat water intrusion in water supplies	No large impacts	Flooding of more inhabited areas. Cooling demands higher, heating demands lower.	Increased exposure to natural disasters; urban water supplies threatened. Sanitation and waste disposal problems expand.	No large impacts expected
Coastal Systems	Up to 19,000 km^2 inundated; 23,000km^2 added to floodplain	Large and productive lowlands flooded; more natural hazards impacts, millions displaced by 1 m sea rise.	Japanese industry in coastal zones, large areas inundated	No large issues	Risk of storm surges in lowland coasts of Holland, Germany Russia, and Ukraine.	Coastal erosion in central coastal areas, particularly in storm impacted west Africa. Flooding of Nile delta of concern.	Highly vulnerable to flooding and inundation
Human Health	None predicted	Increase in vector and water borne disease, malaria, dengue, and schistosomiasis	Increased transmission of vector borne disease	Small increases in disease and heat induced health problems	No major changes	All types of disease exacerbated by malnutrition would further damage the overall health of the people of Africa.	Small increases in disease and heat induced health problems.

Source USEPA, www.epa.gov/globalwarming/publications/reference/ipcc/summary/page4.html chapter are inexorably linked to global climate change --- water as a scarce resource, desertification, and deforestation are prime examples of this. The data are uncertain in producing absolutes of where impacts will be seen, but does suggest that the basic carrying capacities of many regions will change, which implies that populations will need to shift in response. Overall, the impacts of global warming as predicted by this review will be a major destabilizing influence on the security of the world and will be a major push factor to create population migration.

3. El Nino/ La Nina.

Some 'news and information reporting' associate the climate phenomenon El Nino and La Nina with the enhanced greenhouse effect and global climate change, but scientists now better understand that the basic process is natural. From history, El Nino is a period of warm water temperatures and increased early winter rain on the coast of South America centered on Peru. The world became concerned with El Nino as these rains, combined with the impacts of deforestation in some areas, produced floods and mudslides that infrequently decimated the region, killing or injuring many people. A second concern with El Nino is the impact that the unusually warm water temperatures has on the rich fishing waters off the coast of Peru. The warmer waters reduce the presence of the nutrients that feed the fish, causing die off or migration of many valuable natural species intolerant of warmer water[20]. The local residents named these periodic changes in weather El Nino because these events generally appeared around Christmas, and thus they associated them with the birth of The Child, El Nino. Note, the term La Nina came from scientists who coined the term to refer to

[20] John Horel and Jack Geisler, Global Environmental Change: An Atmospheric Perspective. (Wiley, New York, 1997), 59-63.

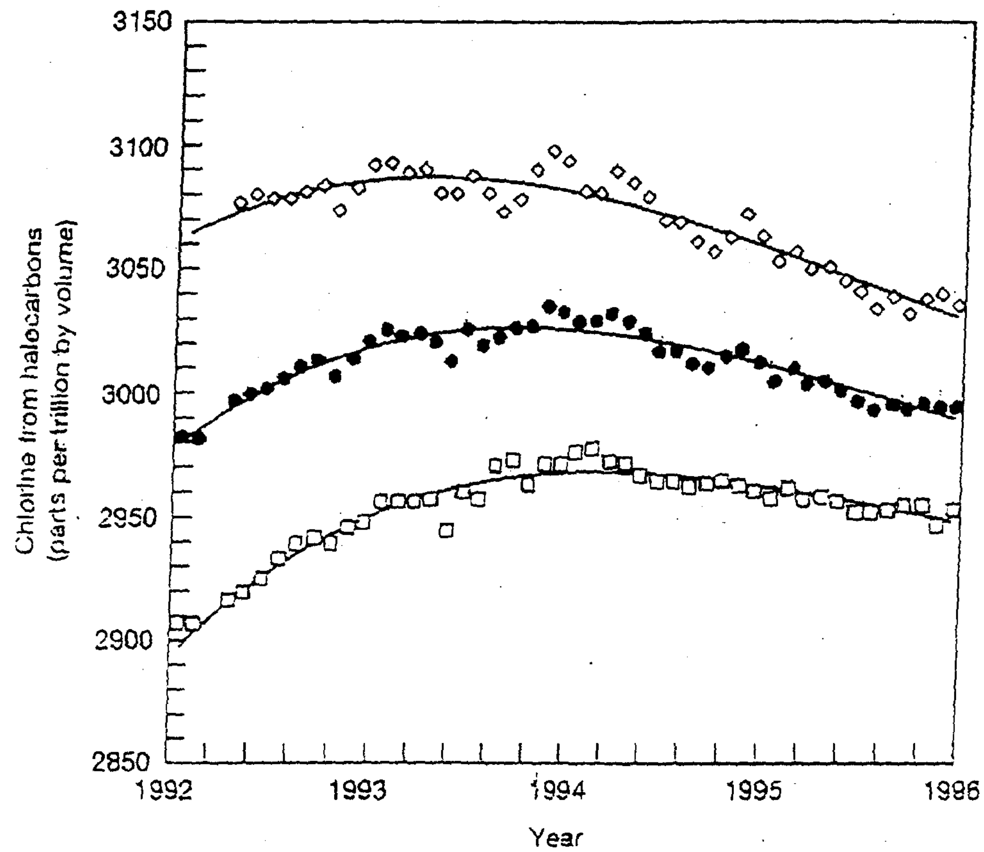
the periods of normal temperatures in the Pacific and thus. normal weather patterns along the coast of South America.

The frequency of the El Nino and exact reasons for the timing of these events remains unknown, but the conditions required to produce an El Nino have been identified. Figure 3-10 shows the surface water temperature profiles in the Pacific Ocean that manifests the corresponding El Nino and La Nina effects. We understand the size of the warm water pool in the Pacific grows at times when the normally cool easterly winds along the equator slow, thereby reducing the cooling impact they have on water temperatures in the Pacific Ocean and bringing the warmer waters closer to South America. As water temperatures rise over a larger area of the Pacific. net evaporation increases greatly. This produces more moisture in the atmosphere to eventually become rain somewhere. and intensifies the low-pressure cells created by the rising warm moist air. These large low-pressure areas become the engines driving air movements throughout the region. The net result is intense rainfall events over areas of the west coast of South America. There are data suggesting that El Nino also produces corresponding drier areas in Central America. but the evidence is not as conclusive.

EL Nino/La Nina has special interest to scientists for two reasons. First. there are questions as to whether global warming may change the frequency and magnitude of El Nino. thus the weather patterns caused by El Nino. Second, El Nino is a natural weather experiment that can be studied to advance our understanding of the scientific relationships between the oceans and our weather. By watching and measuring the cause and effect relationships of the weather generated during El Nino and La Nina periods, we can better build and test our weather models. From an environmental security standpoint the military is

FIGURE 3 -11

CHLORINE IN THE UPPER ATMOSPHERE



= Measured in Southern Hemisphere
• = Measured in Global Average
0 = Northern Hemisphere

Source: Fred Mackenzie. Our Changing Planet, (Prentice Hall. NJ 1998) 414.

concerned primarily with the impacts of El Nino. We have already seen our military conducting humanitarian relief missions in South America in response to the floods and mudslides associated with these phenomenon, therefore the more we understand them, the better we can prepare to respond. Further, if global warming makes El Nino more common, as some predict, this could become a significant issue for U.S. Southern Command.

4. Ozone Depletion in the Atmosphere.

a. The science:

To begin, there is a good ozone in the air and there is a bad ozone, and it is very easy to confuse the two. Bad ozone is really not a subject of this discussion, but is the ozone that exists in lower atmosphere within the living space of plants and animals. Chemically, ozone is a very reactive oxidizing agent, similar in properties to chlorine bleach, with the ability to damage most organic materials. This bad ozone kills vegetation, burns your lungs at even small concentrations, and has several other negative impacts to the extent that it is a primary air pollutant strictly regulated by USEPA.

The good ozone, which is the subject of our concern here, is the ozone that exists in the upper atmosphere, primarily being produced in the upper stratosphere (25-50 kilometers) and stored in the lower stratosphere in a band 10 to 20 kilometers above the earth. Recall our discussion of the photochemical properties of the greenhouse gases and how each gas adsorbed specific wavelengths of radiate energy at different rates. Ozone is a strong adsorber of ultraviolet light (UV), wavelengths below 0.28 micrometers. Our sun emits a large quantity of this energy spectrum into the upper surface of our atmosphere. If allowed to reach the ground, the UV radiation would produce significant harm to many of the living organisms on earth, man being one of our special interest. Large doses of radiation at these wavelengths are known to increase the incidence of cancer in humans, and have many documented deleterious impacts on other animals and many plants. Depletion of stratospheric ozone became an issue when a hole in the ozone layer over the South Pole was first detected in 1985 with the use of new space-based remote sensing technologies. Considerable research has gone into understanding the complex chemistry involved in ozone depletion and determining its causes. Scientists have identified chlorine compounds, particularly chlorinated fluorocarbons (CFCs) as the primary culprits in the mystery. The chemical reactions are complex -- light activated processes where ozone is broken down to oxygen with chlorine serving as a catalyst in the reaction, without being consumed. These reactions occur at higher rates at the South Pole because the temperatures are cold enough to form crystals that also catalyze the reaction. Because chlorine is not bound into the products of the reaction, a small amount of chlorine continues to propagate these reactions for long periods. Freons (CFCs) represent more than 50% of the ozone depleting chemicals already in the stratosphere and have an atmospheric lifetime of 80 years[21]. There is good news from this story and one that we should consider very important from the environmental security standpoint because it proves that global environmental problems can be resolved at the international level. As we developed our scientific understanding of the causes of ozone depletion and its consequences, and recognizing that we had technical solutions to reduce release of ozone depleting substances, the world was able to reach agreement in the Montreal Protocol of 1987 to phase out the use of CFCs. As depicted in Figure 3-11, the chlorine concentrations in the atmosphere have begun to decline, however, the long residence times of

[21] Noel de Nevers, Air Pollution Control Engineering, (McGraw-Hill, Boston, 2000), 526.

many of the different ozone depleting compounds suggests full recovery is going to require into the next century.

b. Impacts of ozone depletion:

There is certainty that reduction of the stratospheric ozone layer has a direct impact on quantity of UV light reaching the ground and all work to date strongly suggest that environmental harm, attacking DNA material in organisms, is being produced in areas under the existing ozone hole[22]. In the inhabited areas most near the ozone hole, South America and Australia, biologists are documenting damage to the light sensitive plant and animal species. The strategic implications of this issue will be analyzed in Chapter 4.

D. Land Use

1. Deforestation.

The goal of this section is to define the relationship between the reduction in the amount of forest area in the world and environmental security. On a global scale, we saw the importance of forests in uptake of carbon dioxide as part of the global carbon cycle, which then serves to regulate the greenhouse effect. This alone would be sufficient reason to consider the security implications of deforestation, but there are more direct issues that result from loss of forest areas in a region. Before we are ready to discuss these we will need to discuss exactly what is deforestation, where and why it is occurring, and finally, the impacts deforestation produces.

Explaining deforestation begins with developing a fundamental understanding of how a forest is defined. As defined by the Food and Agriculture Organization of the United Nations (FAO), a forest is where the tree crowns cover at least 20 % of the surface area in a developed country and 10% of the surface area in a developing country. The logic for two levels of coverage based on the economic state of the country is certainly not based in science, but we will defer to this definition only because the FAO has the best available world-wide data on the state of the world's forests and these data apply this definition[23].

Scientifically, there are many different ways to classify forests. Forests are identified by their requirements for temperature, soil types, and moisture requirements. For example, Strahler in his physical geography text divides forests into 6 separate classifications[24]. This level of detail is beyond our needs and the data describing deforestation is not available at that level of detail. therefore, we will deal with forests as either temperate or tropical. Figure 3-12a depicts the worldwide distribution of forest with a box showing the regions of tropical growth climates. These classifications generalize the effects of temperature and moisture based on the latitude of the region, but cannot deal with localized impacts. altitude as an example.

Tropical forests, located in the wet, always warm mid-latitude belt centered around the equator, occupied 1.8 billion hectares in 1990[25]. As seen in Figure 3-12a, nearly all tropical forests in the world today exist in the developing countries. These include both the rainforests with constant leaf cover and monsoon forests, differentiated because they lose

[23] Food and Agriculture Organization of the United Nations (FAO), Forest Resources Assessment 1990: Global Synthesis.
[24] Alan Strahler and Arthur Strahler, Introducing Physical Geography, (John Wiley, New York, 1996), 207-216.
[25] Food and Agriculture Organization of the United Nations (FAO), Forest Resources Assessment 1990: Global Synthesis, as reported at: www.igc.apc.org/wri/wr-96-97/lc_ttxt2.html, April 2000.

FIGURE 3 -12a

Distribution of Forests Worldwide

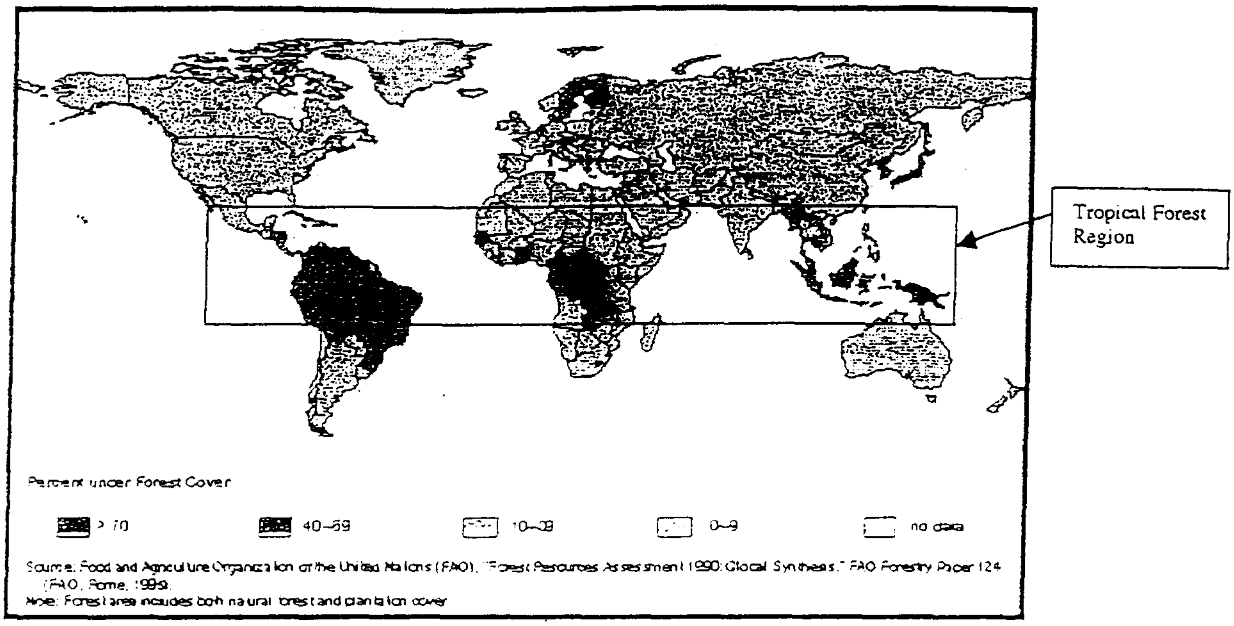
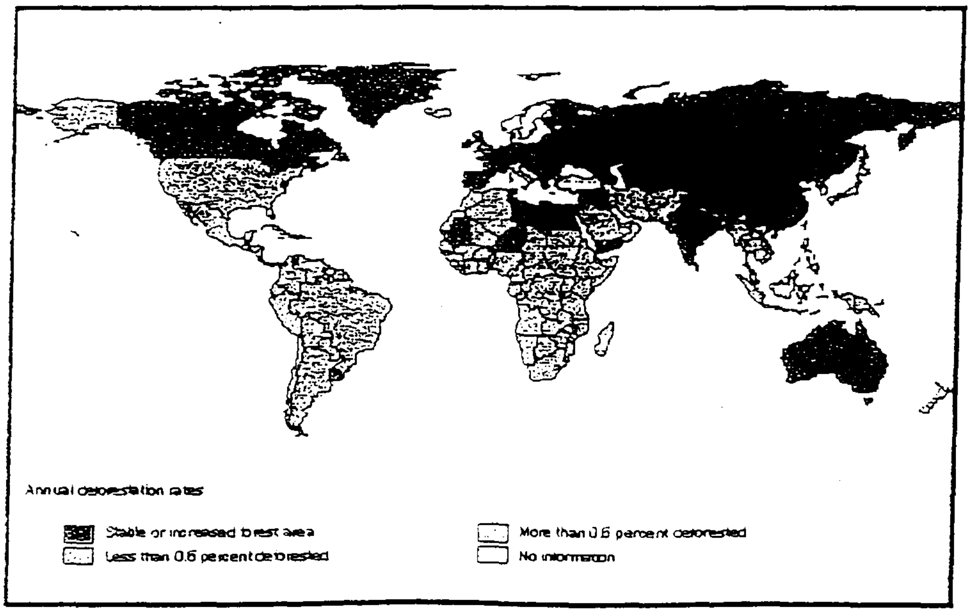


FIGURE 3 - 12b

Estimated Annual Deforestation Rates, 1980-1990



Source: Food and Agriculture Organization of the United Nations. Forest Resources Assessment 1990. Paper 24 (FAO. Rome. 1995) Annex 1.

their leaves in a dry season. Because of the thickness of the vegetation and the perennial biological activity, tropical forests are the world's most productive regions for carbon dioxide fixing. Rainforests are the most biologically diverse biome on earth with literally thousands of species per hectare.

Temperature forests cover a much wider variety of both deciduous and evergreen forest types, and much more of the area of the world, 2.4 million hectares as reported in the FAO 1990 study[26]. Temperate forests include both deciduous and evergreen species of trees capable of survival in all but the coldest and/or highest altitudes in the world. Though not as productive in carbon cycling or diverse in species, the ability to propagate over large areas of the world make the temperate forests a critically important worldwide resource.

Deforestation, throughout time, has been the most fundamental action of human modification of the environment. Trees are removed to clear land for farming, to provide lumber for building, to provide energy to heat and cook, and for many other economic activities. In a sense, a primary difference between developed and developing countries is developed countries have reached an equilibrium with their renewable forest resources.

We will define deforestation as the loss of tree cover to below 10 or 20 percent crown coverage as defined by the FAO. Based on this definition, Figure 3-12b shows the rate of worldwide deforestation for 1980-1990. These data document that deforestation is occurring at the highest rates in the developing countries and within the tropical forests. Over the period 1990-1995, developed countries showed a net growth in forest area of 0.12 percent per year[27]. Some caution must be taken when considering this number because it hides a loss in natural forest. In the FAO data these losses were more than compensated by increases in

[26] Ibid.
[27] Fred T. MacKenzie. Our Changing Planet, (Prentice Hall, New Jersey, 1998), 254-257.

plantation acreage. This same source reports the total annual deforestation percentage in the tropics as 0.8 percent or 15.4 million hectares lost per year from 1980-1990 (that is an area about the size of the state of Georgia each year).

Deforestation has both a natural component and one of anthropogenically induced change; we are limiting our focus to the later. In the developing countries trees are removed to expand farm and grazing lands, provide fuel wood, and for the economic benefits of logging. For the first two purposes population pressure is a direct and acute factor affecting the rate of deforestation. The need for more land for food production is the obvious impact, but with 35 percent of the world's population relying on wood for cooking and heating, the pressure is doubly intense[28], and most of these are in areas without good options to replace wood fuels. Economically, trees are a primary export for many of the developing countries, particularly in the tropics. Logging may be conducted by the government or by an international logging company working under some contractual arrangement with the government. The profits from logging are essential in many of these countries to help pay the costs of modernization and in many cases, the costs of a growing and urbanizing population. It should not be overlooked that the developed countries are the recipients of most of the wood generated from logging in the developing countries. The FAO deforestation data indicates that developed countries have reached a sustaining level in forest management, but the reality is that they are maintaining their forests by satisfying their thirst for wood from the forests of the developing countries. Japan for example, a country with more than 60 percent forest cover and showing no net change in forest area, consumes 50 percent of tropical wood cut[29].

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[28] Ibid. 267.
[29] Ibid.267. World Resources 1996-1997, www.igc.apc.org/wri/wr-96-97, 217.

In the developed countries, deforestation results from the economic pressures to sustain an often dying logging industry, but is further exacerbated by the impacts of air pollution. Air pollution not only directly kill trees, but also can damage trees so that they are more susceptible to insect and microbial infestation, which eventually leads to die-off. In the United States we have measured the impacts of large power plants damaging forests in the southeast and northeast. Many regions in central Europe are experiencing similar problems[30].

In both the developing and developed countries, as we introduced earlier, global climate change may impact the size and distribution of a region's forests. Global climate change can impact temperature, the quantity and temporal distribution of water, and soil structure over time. These in turn, determine the type of vegetation, including forests, an area can naturally sustain. These facts are irrefutable; however, the actual regional impacts are very difficult to identify separate from naturally occurring change and therefore are difficult to predict.

2. Impacts of deforestation.

The impacts of deforestation range from the very subtle changes in climate that loss of forest areas may induce to the dire life-threatening issues that the absence of fuel wood can cause. In the context of environmental security, consider the examples of Ethiopia and Haiti. In 1900 Ethiopia was 45 % forested[31] while today, only 2.5 percent remains forest and woodland[32] while Haiti has gone from mostly tree covered to nearly barren. The strategic discussion of linkages between security and environment are the subject of the next chapter,

[30] Fred T. MacKenzie, Our Changing Planet, (Prentice Hall, New Jersey, 1998), 327.
[31] Ibid, 257.

but it is justifiable to surmise there is a correlation between the unrest in these countries and these drastic changes in their environment.

Deforestation is not a completely anthropogenic process. Natural changes in weather, forest fires, forest disease, all occur at natural rates producing changes in the type and locations of the world's forests. Through observation of natural changes we enhance our understanding of how the man induced deforestation will impact an area. Armed with what we have learned from natural systems, we can expect numerous serious implications for deforestation. For analysis of environmental security the most critical are:

- Reducing the carrying capacity of the land.
- Reduction in the forests as a component of the carbon cycle and the resultant loss of CO_2 removal capacity.
- Loss of biodiversity with all of its known and unknown implications
- Increased flooding, loss of soils with the resultant mudslides and waterway siltation.
- Economic impacts from loss of forests as a renewable resource.

It is well beyond the scope of this research to discuss the scientific basis for each of the complex concerns attributed to deforestation above. In an effort to summarize these concerns in a format that will support strategic analysis later. Table 3-4 describes the possible impacts of deforestation on the basis of tropical and temperate regions of the world, further divided into developed and developing countries. In each impact box of the table an arbitrary qualitative rating has been assigned based on the severity of impact should deforestation

[32] World Resources 1996-1997, www.igc.apc.org/wri/wr-96-97, 216.

TABLE 3 - 4
Potential Impacts of Climate Change

Possible Issues	IMPACTS Tropical (Developing countries only	IMPACTS Temperate, Developing Countries	IMPACTS Temperate, Developed Countries
Carrying Capacity - Loss of soil from erosion - Less fuel wood - Less water available - Loss of soil moisture for crops - Land cannot sustain crops	-- Increased disease -- Food production reduced -- Famine -- Drought -- Causes population migrations {MODERATE}	-- Loss of fuel food increases disease -- Reduced water supply -- Reduced soil moisture impacts food supply {HIGH}	-- Water supply reduced -- Soil moisture loss reduces food production {SMALL}
Carbon Cycle · Global Climate Change - Global warming - Storm frequency and intensity -El Nino La Nina	- Less Carbon dioxide absorption - Slash and burn releases carbon dioxide inputs - Change in evaporation rates causes shifts in water availability {MODERATE}	- Population migrations - Lower soil moisture in growing season - Higher temperatures impact health {HIGH}	-- Storm frequency impacts -- Minor impacts and shifts in land use {MODERATE}
Biodiversity - Loss of species - Loss of habitat	- 40 times more diverse than temperate forests - 1,000s of species lost per year - Critical habitat lost - Loss of indigenous native tribes {HIGH}	- Species dieoff - Habitat lost for endangered species {SMALL}	-- Natural forests loss could impact a number of species {SMALL}
Hazards -- Loss of life -- Increased disease -- Economic costs of response	- Increased runoff rates produces floods - Mudslides and siltation of streams {MODERATE}	- increase flooding damage - Loss of life - drought more common {MODERATE}	-- Increased storm frequency {SMALL}
Economics -- Short term cost/benefits -- Long-term costs/benefits	- Debt payment possible - Development funds created - Long-term loss of sustainable resource - Unknown value of biodiversity lost {HIGH}	- Long-term loss of sustainable resource {MODERATE}	- Mitigation of storm impacts - Quality of life impacts {SMALL}

High - Potential to significantly alter existing environmental setting.
Moderate - Measurable negative impacts expected.
Small - Small net change in environmental conditions. well within capacity for adjustment

continue at the rates predicted in Figure 3-12. What we see from this summation is that the impacts from deforestation will be most severe in the tropical regions, not unexpected because these are the regions of high deforestation. It appears the tropical regions are trading short-term economic benefits for an unknown future. From a world perspective, the developed countries share a portion of blame for the concerns for global climate change caused by tropical deforestation because they are the markets for the wood being harvested at a rate much faster than it is being regenerated. Further, developed countries understand how good management practices would allow trees to be harvested without the damage done by large scale clear cuttings, but pursuit of higher profits by international business hinder use of best management practices.

As a security issue in the developing temperate forest countries, impacts on carrying capacity have the most direct and dire effects. In the developing world the land must provide water, food, and energy to heat and cook. Loss of fuel wood reduces the ability to properly process food that could yield both malnutrition and disease. Clearing of former forestlands for grazing and farming can have the opposite effects intended. In many parts of the world, because of shallow soils and high rainfall rates, forests are the only appropriate use for the land. Removing the trees destroys the root structure that holds soils and increases the intensity of the runoff and allows the soil to be quickly washed away. Deforestation changes the storage of rainfall and has other detrimental effects on the regional hydrologic cycles, with a net effect of less available water over a year.

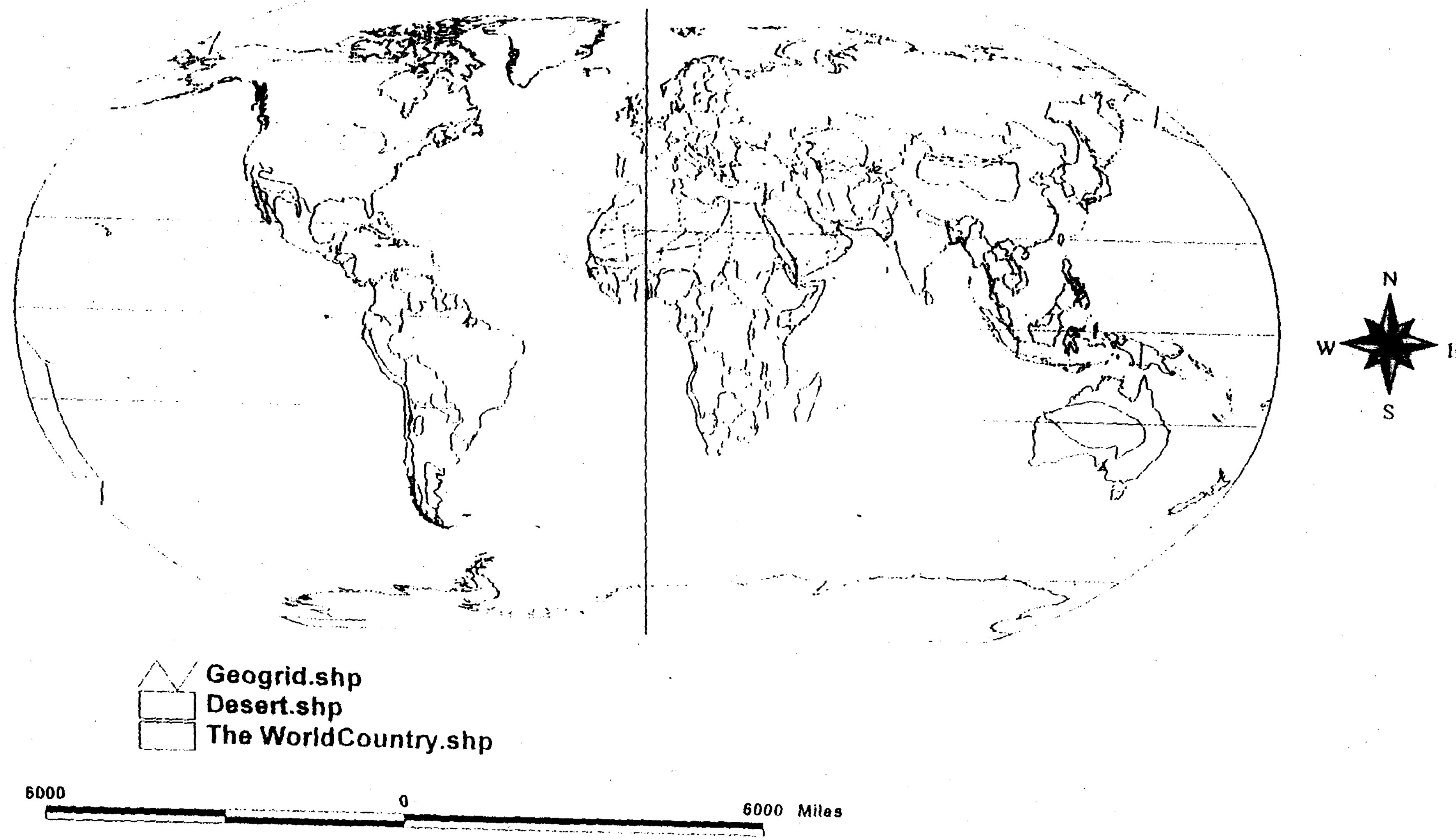
3. Desertification.

Today, some 40 % or 60 million square kilometers of the world's land area is classified as dry climate with some 10 million of this land being considered desert[33]. Figure 3-13 represents the distribution of areas of deserts across the world. Desertification is a process where both water and soil become scarce to the point of being unable to sustain a vegetative cover. Loss of cover allows for increased soil erosion, primarily by wind, further reducing the carrying capacity of the land, even if water was again available. Just as with deforestation, there are both manmade and natural causes of this process. Natural fluctuations in rainfall change the shape of a desert, usually working around the boundaries of an existing desert. Overgrazing, mining of groundwater, and over use in farming can also produce desertification of an area. The African Sahel is the most striking example of desertification or land degradation seen in modern times. The Sahel is the belt around Africa lying at about 15 degrees North latitude and forming the southern extent of the Sahara desert. Increases in the nomadic herding population of the region in combination with a drought that extended from 1968-1991, produced desertification in the area[34]. The result of desertification is a drastic reduction of carrying capacity until conditions allow regeneration of the vegetative cover, if the impacts of erosion do not are not too severe.

Global climate change can produce desertification in the same manner it is manifested by natural climate change. Our problem today is distinguishing natural from man induced desertification, and even more difficult, predicting the changes that will occur from any climate changes resulting from the enhanced greenhouse effect. Based on experience to date,

[33] John Houghton, Global Warming: the Complete Briefing, (Lion Publ., England, 1994), 101.
[34] Alan Stahler and Strahler, Introducing Physical Geography, (John Wiley, NY, 1996), 170.

FIGURE 3 - 13
Desert Climates of the World



SOURCE: Rand McNally, Goode's World Atlas, 1995, page 11.

TABLE 3 - 5

Water Data for Countries with Low Domestic Supplies

COUNTRY	Total Domestic Water Use Liter/d/per	Total Water Withdrawal km3/yr	Total Renewable Supply km3/yr	Total Use M3/per/yr	Domestic Use %
Gambia	4.5	0.02	8	23	7
Mali	8	1.36	67	148	2
Somalia	8.9	0.81	15.7	108	3
Mozambique	9.3	0.6	216	39	9
Uganda	9.3	0.2	66	11	32
Cambodia	9.5	0.52	498	69	5
Tanzania	10.5	1.17	89	43	9
Central African Rep.	13.2	0.07	141	23	21
Ethiopia	13.3	2.2	110	45	11
Rwanda	13.6	0.77	6.3	106	5
Chad	13.9	0.18	43	32	16
Bhutan	14.8	0.02	95	15	36
Albania	15.5	0.2	21	94	6
Zaire	16.7	0.36	1019	10	61
Nepal	17	2.68	170	103	7
Lesotho	17	0.05	5.2	28	22
Sierra Leone	17.1	0.37	160	89	7
Bangladesh	17.3	22.5	2357	211	3
Burundi	18	0.1	3.6	18	36
Angola	18.3	0.48	184	48	14
Djibouti	18.7	0.01	0.3	24	13
Ghana	19.1	0.3	53	20	35
Benin	19.5	0.14	25.8	31	23
Solomon Islands	19.7	0.001	44.7	18	40
Myanmar	19.8	3.96	1082	103	7
Papua New Guinea	19.9	0.1	801	25	29
Cape Verde	20	0.03	0.3	70	10
Fiji	20.3	0.03	28.6	37	20
Burkina Faso	22.2	0.38	17.5	42	19
Senegal	25.4	1.36	39.4	186	5
Oman	26.7	1.22	1	325	5
Sri Lanka	27.6	6.3	43.2	503	2
Niger	28.4	0.5	32.5	65	16
Nigeria	28.4	3.63	280	33	31
Guinea-Bissau	28.5	0.02	27	17	60
Vietnam	28.8	5.07	376	81	13
Malawi	29.7	0.94	18.7	107	10
Congo	29.9	0.04	832	18	62
Jamaica	30.1	0.32	8	157	7

we can expect that changes will occur within existing dry climates and on the margins of existing deserts. In some places this may be a receding of the existing desert because of increased rainfall, in others it is likely to produce desertification.

4. Impacts of Desertification:

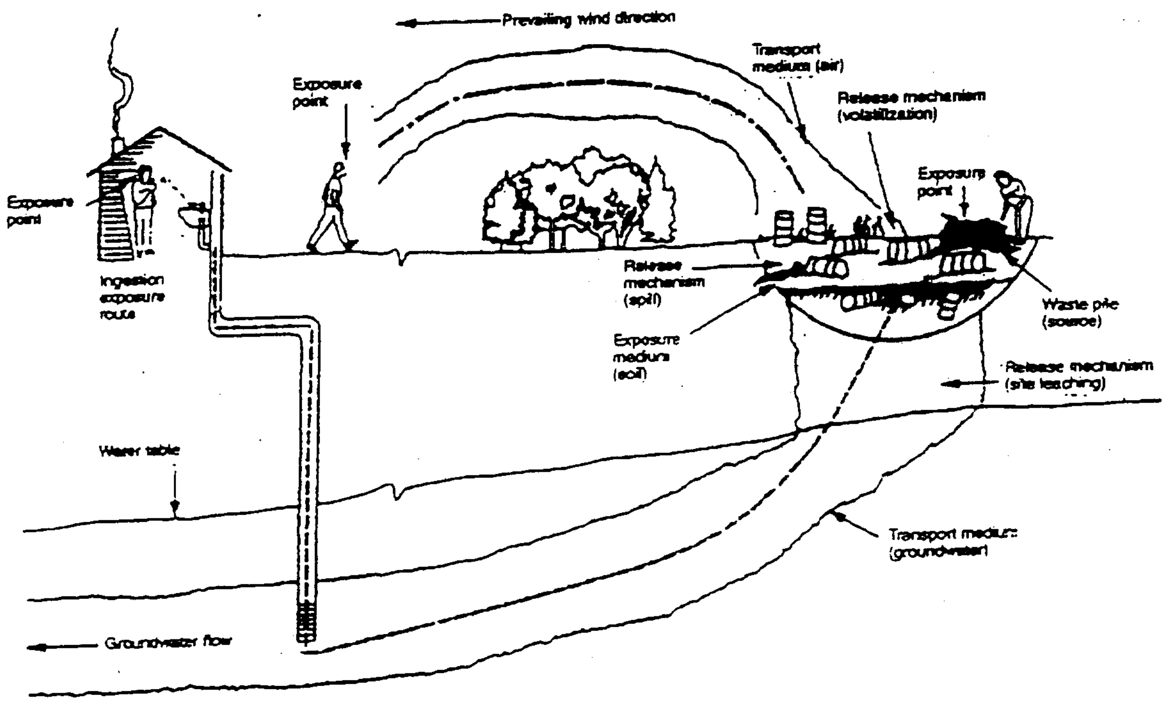
The direct impact of desertification is the complete loss of carrying capacity of an already fragile biome with the indirect effects being the migration of people previously supported by the area. Our ability to predict desertification is limited to our ability to predict natural weather patterns concurrent with understanding the impacts of anthropogenically induced global climate change, primarily from the enhanced greenhouse effect. Expansion of the world's deserts will be at the expense of steppe type environments, which are inhabited by grass and scrub vegetation and most commonly support sparsely populated herding cultures. More human pressure in these regions could accelerate the desertification process by increased grazing and fuel wood gathering. Overall, the spiraling impact of desertification displacing people has been seen in the Sahara regions already and is a potential impact in other parts of the world as a result of global warming.

5. Hazardous Waste Disposal:

Toxic and hazardous materials are a uniquely modern legacy humans have distributed over the entire world. Over 30,000 different chemicals, each manufactured for some 'beneficial' use, have become absolutely ubiquitous throughout the world. Most of these chemicals and the billions of pounds of waste generated as by-products in their manufacturing process are carcinogenic, mutagenic, or teratogenic, making their use and disposal hazardous to living organisms. First, many of these chemicals biodegrade very

FIGURE 3 – 14

Pathways of Human Exposure
to Hazardous Substances



SOURCE: King. Environmental Engineering (AAEE. Annapolis. 1999) page 436. USEPA 1989.

slowly, therefore, when released into the environment have the capacity to produce harm for a long time. The hazards of these chemicals are manifested through a chain of events, 1) their intentional or accidental release 2) human exposure through direct contact, ingestion of contaminated food or water, or inhalation of airborne chemicals, and finally, 3) accumulation of enough of the toxin to produce an physiologic response.

Let's use the illustration in Figure 3 - 14 and a widely known environmental contaminant, PCB (polychlorinated biphenyl), as an example to represent the hazards posed by modern chemicals. PCB was long used as an insulating fluid in electrical devices because it possessed the appropriate electrical properties while not being volatile or flammable. Over the past 50 years nearly all large transformers you would have seen on electrical poles and in substations would have been filled with this pale yellow liquid.

Step 1 --- Through maintenance activities, accidents causing spills, and improper disposal activities, a large quantity of PCB has been released to the environment over the years. Also, in manufacturing PCB waste by-products were disposed of in ways that contaminated soil and drinking water supplies. In just one case, a large manufacturing operation dumped thousands of tons of PCB into the Hudson River to the point that the fish in the river today remain dangerous for human consumption years after dumping has ceased.

Step 2 --- The pathway for chemicals released to the environment reaching a human is best understood through examination of Figure 3 – 14. The most common exposure pathway is for the contaminant to reach a drinking water source where it is collected or transported to unknowing consumers. This is depicted by the water well in the figure but is more commonly associated with public water supply systems. Public water supplies in our country are monitored for hundreds of common contaminants to assure this does not happen. In the developing world this is an expense they cannot afford. For most of the chemicals that dissolve in water at harmful levels, which includes are large number of chemicals, standard water treatment practices DO NOT remove the toxins.

Step 3 --- Unlike the catastrophic occurrences such as Bhopal, India where thousands were killed and injured from a toxic cloud, most toxins act in an insidious manner, requiring long periods of time for the body to accumulate sufficient concentrations to manifest symptoms. Of course with contaminated water, food, or air, this time is available. In the case of PCB, it has an IDHL of 5 milligrams per cubic meter (mg/M^3)[35], which translates to a very small amount is Immediately Dangerous to Life or Health --- because of its known carcinogenic risk. This extreme toxicity is even further exacerbated by PCB's long persistence in the environment[36]. PCB ingested in water or fish can accumulate in the body until, often decades later, cancer results[37].

The military have their own unique types of hazard waste operations that have the potential to pollute the environment, including explosives, waste oils, fuel, cleaning solutions and other maintenance fluids, chemical agents, and nuclear material. The DOD is now spending billions per year to clean up our past indiscretions in disposal and spillage of these materials. In Chapter 4 we will discuss opportunities to share our lessons learned with other

[35] NIOSH, Pocket Guide to Chemical Hazards, (US Public Health Service, 1990), 68.

[36] C. W. Fetter, Contaminant Hydrogeology, (Macmillan, NY, 1993), 301.

[37] Figure 3-18 explains the process of environmental contamination on the basis of disease transmission.

military forces so that they do not make the same costly mistakes or can gain from our experience to expedite remediation efforts.

6. Issues of Hazardous waste:

The issues of hazardous waste all relate directly or indirectly to human and environmental health. Just as Chernobyl made thousands of square kilometers uninhabitable for years, toxic releases from industrial manufacturing and waste dumping directly impact people all over the world. This occurs primarily through pollution of groundwater making it dangerous to drink and air pollution. In the developed world this water would not be consumed or would be treated to safe standards. However in the developing world conditions are such that the contamination may not be detected, there may be no alternative sources, and treatment is too expensive, all summing to produce an extreme hazard for the developing world's health. Air exposures to toxic chemical occur in the developing world where modern pollution abatement technology is not applied to industrial smokestacks. A senior Russian environmental scientist in 1995 reported areas of his country where the infant mortality rate had reached 50 % because of toxic metals released to the air from smelting operations[38]. Land use for farming and living is also degraded or lost through toxic contamination events. Overall, toxic pollution can severely stress the people and environment of a region and may be a source of insecurity for a region.

[38] Non-attribution Lecture by a member Russian Academy of Science, at the United States Military Academy, 1994.

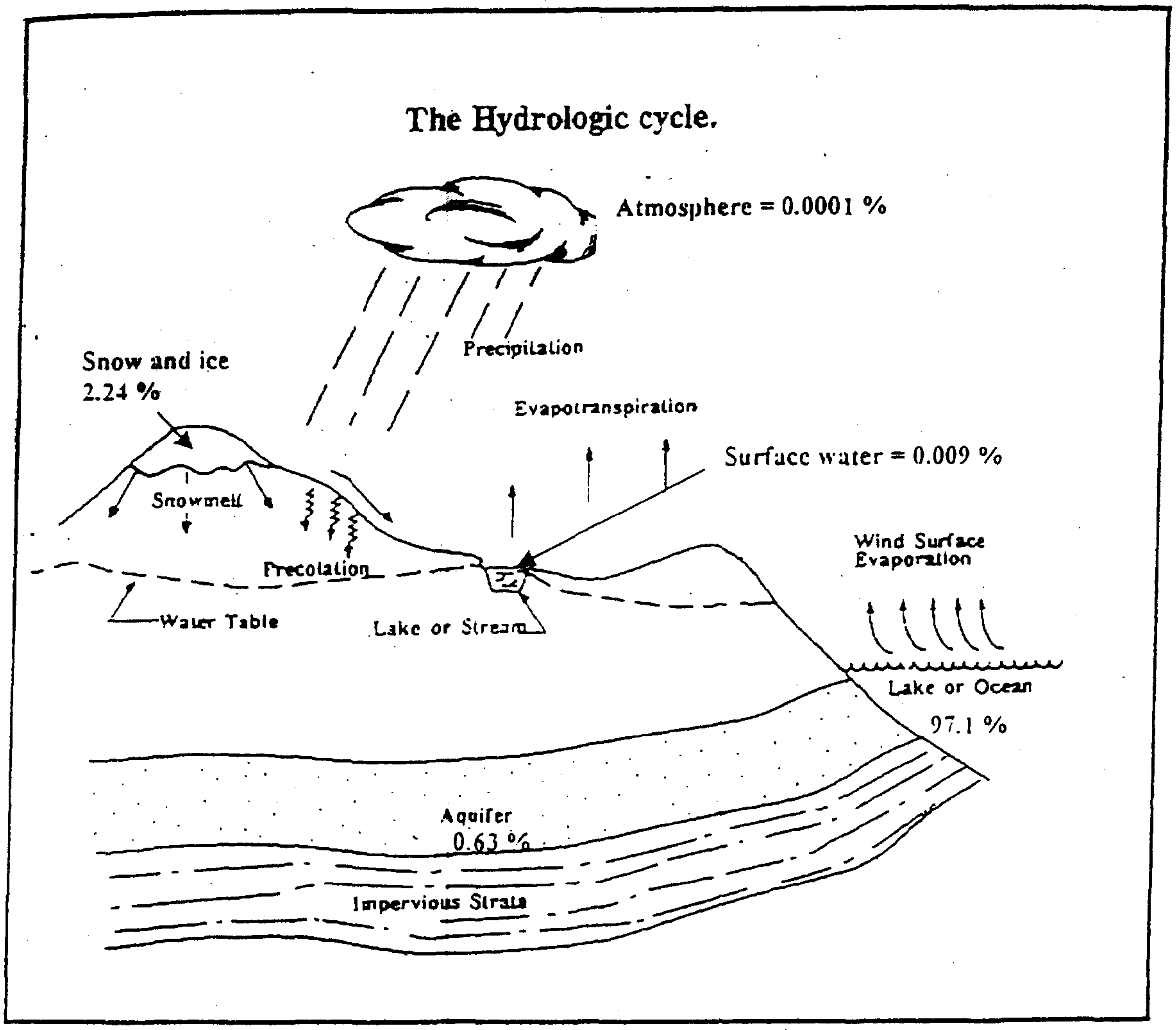
E. Water Use

1. Fresh Water Supplies:

Water is a critical element for life and for modern developed society is an essential component of economic success. Most people are familiar with the hydrologic cycle depicted in Figure 3-15, here showing the relative quantities of water stored in different segments of the environment. This Figure reminds us of the relatively small quantity of freshwater available for the many demands for fresh water --- domestic consumptive use, sanitary use, industrial use, thermoelectric power cooling water, hydroelectric generation and agriculture irrigation. Quantity can be measured in both the total demand of a country, but is better represented in terms of the quantity per person per time. Figure 3-16 shows over the last century world water consumption in both of these units of measure. Clearly the eight-fold increase in total water demand is dominated by population statistics, but increased demand per person has also doubled over the century. An example of the impact of development has on water use can be seen by comparing water use in the U.S. with world use. In 1900, world demand was approximately 300 cubic meters per person per year (m^3/p/yr) while in the same units U.S. demand was 700. In 1980, world use had grown to 700 m^3/p/yr, while in the US demand had reached 2700 m^3/p/yr, and remember these units factor population growth out of the equation[39]. The point to consider here is that transforming into a developed society, to this point in history, has greatly increased the requirements for water. Our problem comes in trying to reconcile Figure 3-15 with Figure 3-16, is that supplies are fixed while demand continues to grow rapidly. There has been progress in management practices, but these have reduced the rate of growth in demand per

[39] Peter H. Gleick, The World's Water, (Island Press, Washington, DC, 1998), 10-13.

FIGURE 3 – 15
DISTRIBUTION OF WATER IN THE ENVIRONMENT

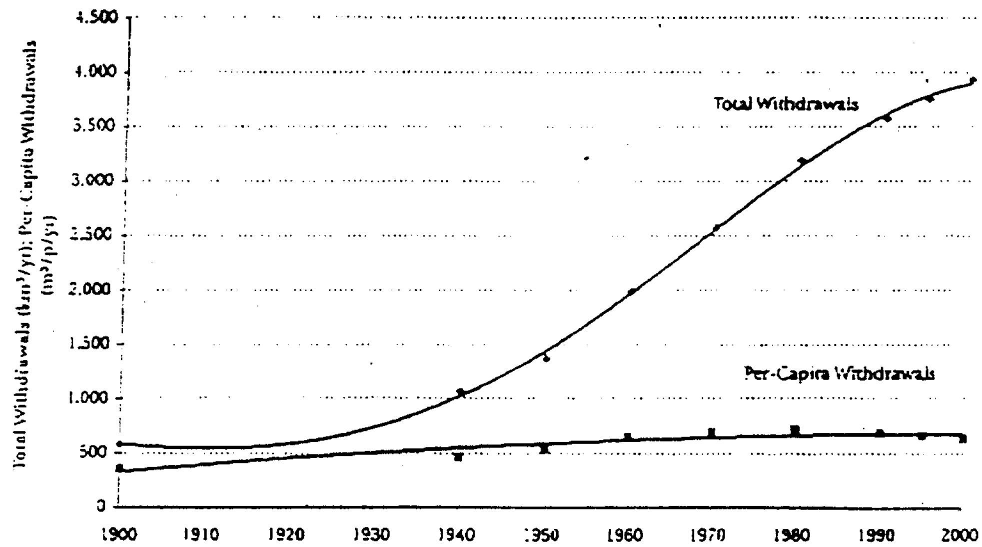


Source: Andre Dzurik. Water Resource Planning, (Rowman & Littlefield, Maryland, 1990) 13.

person. not the total requirements. The U.S. can be seen as a recent good news story here. By 1995 demand in the US had dropped to 2.200 cubic meters per person per year. producing a flattening of total demand for the past 20 years. This was achievable only in concert with a small population growth rate over this same period.

FIGURE 3 – 16

World Water Use Rates,
Total and Per Capita



SOURCE:Peter Gleick. The World's Water. (Island Press. Washington. D.C.. 1998).11.

The bottomline line for water as a resource is:

-- Demand will continue to increase steadily and in direct ratio to population growth.

-- Modernization (development) will increase demand, not reduce it.

-- We can expect areas the water shortages seen now to become more critical while many areas of the world will reach their limits of available resources.

Figure 3-15 shows that renewal water resources come from precipitation recharging the surface water streams and lakes, and the water stored in the ground. This recharge is temporally and spatially dependent, or in simpler terms, we don't have water problems it just comes in the wrong places at the wrong times. To overcome these problems we build dams to store water for use in drier periods and we build aqueducts to transmit water areas without sufficient resources to meet their demands, but these mitigative actions have limits to their effectiveness. Dams are expensive solutions having application only in ideal circumstances of available space, high seasonal flows, and no conflicting water uses. Aqueducts, also expensive, require that some region is willing to supply water to another region and that access between the two areas can be assured. In the military context we talk about the security issues of having water supplies vulnerable to the actions of others or serving as a possible critical target in a conflict.

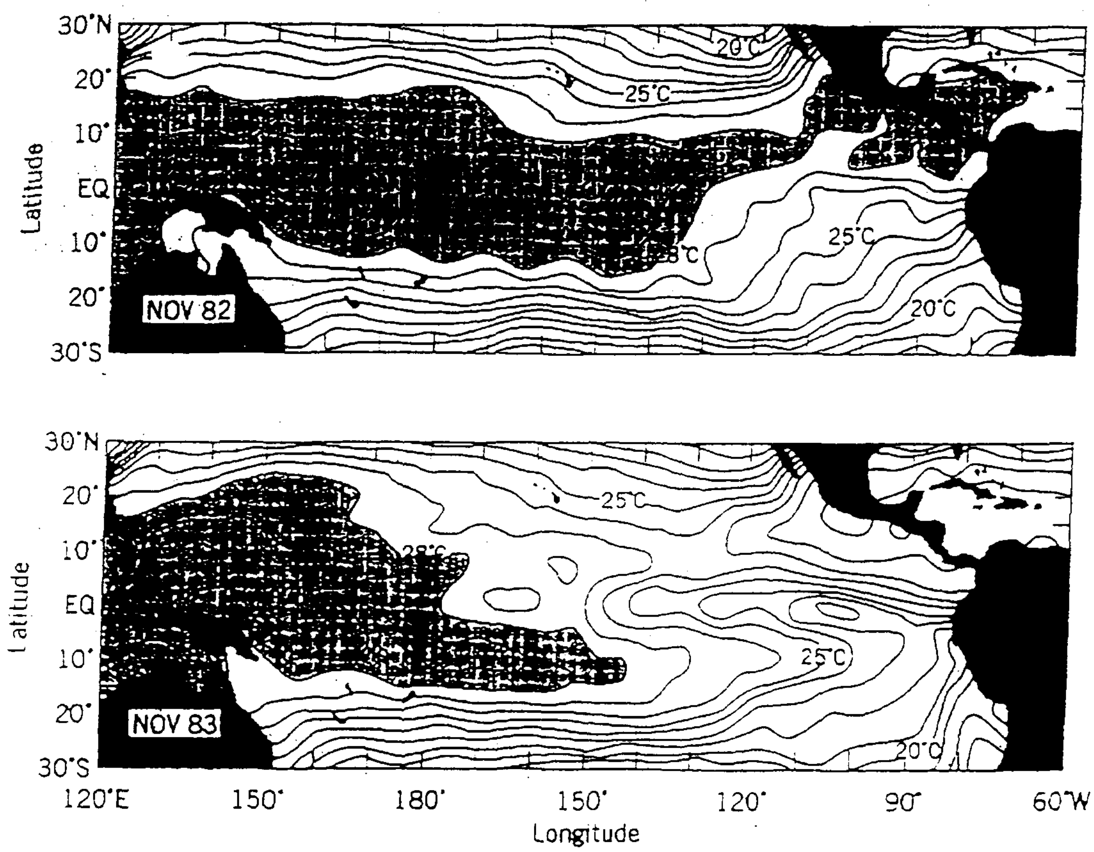
What is the basic water requirement for a person on a daily basis to sustain life? This value must include water for drinking, cooking, and basic sanitation requirements such as personal hygiene and cleaning. One estimate with good acceptance is 50 liters per day per person[40]. Table 3-5 identifies those countries of the world that did not provide this quantity of water as of 1990. Understanding the causes of this shortfall comes from analysis of both the available supplies and an examination of withdrawal and use rates. First, only a small portion of the annual renewable resources will actually be usable in the sense that it is

[40] Ibid. 44.

FIGURE 3 - 10

SURFACE WATER TEMPERATURES IN THE PACIFIC OCEAN

Top view shows El Nino conditiosns
Bottomline shows normal conditions (La Nina)



Source: John Horel and Geisler. Global Environmental Change: An Atmospheric Perspective. (Wiley. NY. 1997) 60.

Haiti	30.2	0.04	11	46	24
Indonesia	34.2	16.6	2530	96	13
Guatemala	34.3	0.73	116	139	9
Guinea	35.2	0.74	226	128	10
Cote d'Ivoire	35.6	0.71	78	59	22
Swaziland	36.4	0.66	4.5	830	2
Madagascar	37.2	16.3	337	1358	1
Liberia	37.3	0.13	232	50	27
Afganistan	39.3	26.11	65	1436	1
Uruguay	39.6	0.65	66	241	6
Cameroon	42.6	0.4	268	34	46
Togo	43.5	0.09	11.5	25	62
Paraguay	45.6	0.43	314	111	15
Kenya	46	2.05	30	85	20
El Salvador	46.2	1	19	241	7
Zimbabwe	48.2	1.22	20	126	14

SOURCE: Peter Gleick, The World's Water, Island Press, 1998.235-244.

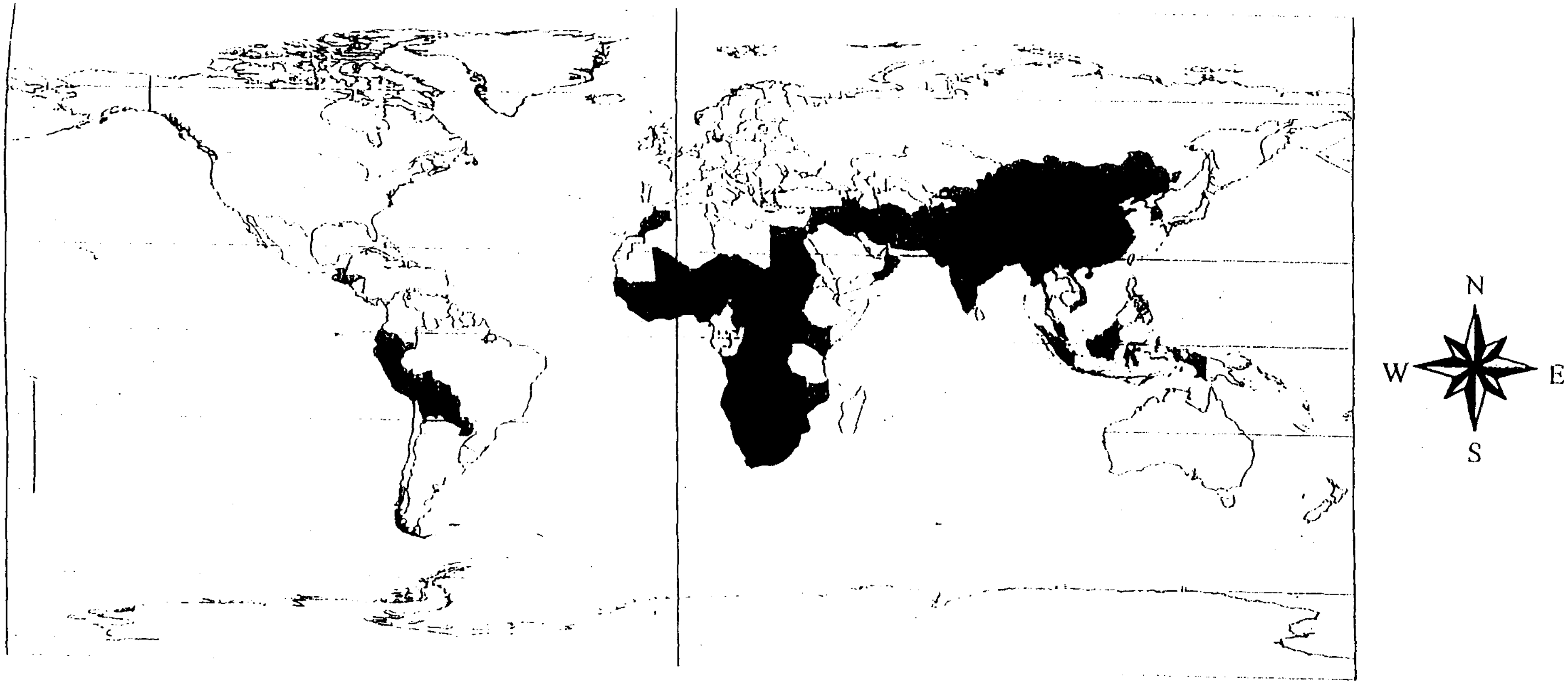
available in the right place at the right time. Analysis even on a country scale may not account for the misdistribution of people and resources. Accepting this shortcoming, Table 3 - 5 shows the renewable water supply, the total withdrawal per person per year, and the percent domestic use rate. From these data we will later be able to better interpret the causes of domestic water shortages in the 50 shortage countries.

Quality is an often-overlooked issue that must be addressed in any discussion of water supply. The World Health Organization estimates that 1 billion people a year contract a waterborne diarrheal disease and that 3.3 million of these people die, per year[41]! This does not account for many other waterborne diseases that inflict pain and suffering pandemically throughout the world. In the developing world a primary quality concern is human waste being disposed of in surface waters contaminating drinking water supplies and this water then being consumed without adequate treatment. The current state of safe drinking water and adequate sanitation in the world is depicted in Figure 3-17. Clean water is a critical issue for parts of South and Central America, most of Africa, and much of Asia.

The developed world is not without it problems with water quality. One disease outbreak in Minneapolis in 1993 caused over 400,000 cases of disease and 100 deaths, this in a region rich in water resources. We possess the technical capability to treat any polluted water to a standard to make it again safe for consumption, but this technology is very expensive. Over the past 30 years great improvements have been made in safeguarding the developed world's drinking water, but in the developing world waterborne disease, toxic waste disposal, and other forms of pollution continue to degrade fresh water resources.

[41] World Health Organization, Community Water Supply and Sanitation: Needs, Challenges and Health Objectives, 48th World Health Assembly, (A48/EOS/96.15, Geneva 1995).

Countries Without Clean Water and Adequate Sanitation



SOURCE: Peter Gleick, The World's Water, Island Press, 1998.

Once basic human needs for water are satisfied, other uses for water can be met with the available supplies. These higher level uses include irrigation, power generation, and the many industrial processes that are high volume users of water, food processing as just one example. In examining Table 3-5, we find the non-domestic use as the difference in percent from the amount shown in the last column. For example, even though Afghanistan and Madagascar fall short of recommended domestic supplies, 99 percent of their total water use is diverted to other purposes, in these two countries this water all goes to agricultural use. One of the great uncertainties in global climate change spilling over to our considerations of water is how weather shifts will impact food production by changing water supplies during growing seasons.

Salinity in water is a major quality issue of concern in agricultural and many industrial uses. Salts present in irrigation water are retained and concentrated in the soil as water naturally evaporates from the upper layers. Over time, without adequate rain to dissolve these salts back into the water for transport away, soil salt levels build up to concentrations toxic to many crop plants. These lands are then lost to production or must change to crops more tolerate of salt. Salination is reducing food production rates in many parts of the world today, mostly in arid regions where lack of rainfall makes recovery times very long. The US is experiencing this problem in isolated parts of the West and Southwest.

Overall, water is a problem of basic survival in at least one third of the world and is a limiting factor in development for most of the world. As a great American sage once said, '*People argue over politics, they fight over water*'.

2. Issues with water scarcity:

The issues with sufficient quality and quantity of fresh water are obvious. but the current and anticipated impacts on the world need to be addressed. Foremost is the impact on health from inadequate and/or contaminated water. This is a two-part problem, the initial part of the equation being sanitation and the second being clean water sources for drinking.

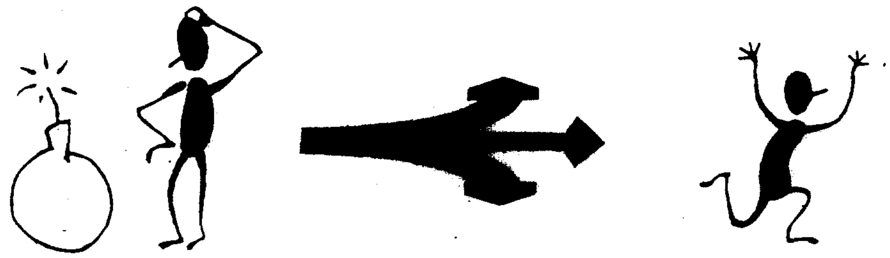
Nearly all infectious disease and thus epidemics in the world today have as their root cause poor sanitation (see Figure 3 - 18 for primer on epidemic disease). Human wastes serve as the reservoir of disease. Depending on the disease the mode of transmission can be water. food. or vectors. but contaminated water is by far the most common vehicle for disease agents. In most of the world water in open or contained sewers is used to convey human wastes away from susceptible human populations to eventually discharge into the nearest naturally flowing stream. In the developed world this sewage is treated to REDUCE the pathogenic organisms before discharge. In most cities of the developing world this sewage flows. untreated or partially treated. into the surface water system. Water scarcity reduces the amount of water available to safely remove this waste from the populated areas. This affords exposure opportunities through direct contact by vectors such as flies and mosquitoes transmitting the disease. or numerous other pathways for disease transmission. The second part of this problem is on the water supply component of the equation. In water scarce regions all available resources must serve as water sources. even those contaminated with human and animal wastes. As noted earlier. we have the technology to clean this water to safe standards. however, the cost of high technology treatment is out of reach for developing countries. In fact, much of the world's population uses water directly from the source, untreated. Consider again the example of Minneapolis mentioned earlier in the chapter, where *Cryptosporidium*, a waterborne microorganism transmitted through a treated public water system, killed over 100 people. In the developing world waterborne Cholera, Salmonellosis, *E. coli*, are every bit as dangerous as an AK-47. The WHO estimates that 2.6 billion people live without proper sanitation, while 1.3 billion people are without safe drinking water[42]. Figure 3-17 shows the areas of the world where more than 25 % of the population lack proper sanitation and safe drinking water. Both in mortality and the cost drain of health care for preventable disease, as reflected in Figure 3-17 water scarcity is having a debilitating impact in the developing world.

Water scarcity is also a major contributor to population migration, a major factor in insecurity in many regions of the world. Saharan Africa and the impacts of recurring droughts in that region have shown this to the world. Water as a resource for production of food, use to produce power, use for transportation, use in industry, etc., all these become security issues when water is 'shared' by countries or different peoples. These issues will be analyzed in depth in Chapter 4.

[42] Peter H. Gleick, The World's Water, (Island Press, Washington, DC, 1998), 40.

FIGURE 3 - 18

A PRIMER IN EPIDEMIC DISEASE



SOURCE (humans, animals, water) — PATHWAY (water, food, vectors) — RECEPTOR (humans)

A basic understanding of the disease transmission and the epidemic process have long been appreciated, with guidance on personal hygiene to prevent illness dating back to the Bible and the Koran. Disease is transmitted following the source-pathway-receptor model illustrated in the cartoon above. The source or reservoir is the location of the active disease agent, typically bacterium or viruses. In most cases of human disease, man is the reservoir. Pathway indicates that there must be a mode of transmission from the source to the receptor. This is the function that water accomplishes most often, but food can also transmit disease as well as person to person contact. The receptor is a person that is susceptible to the contagious agent. Not all people exposed to an agent will contract the disease; incidence of disease is heavily dependent on the dose received and the susceptibility of the receptor (victim). In disasters where the population is weakened by malnutrition, stress, and exertion, people become much more susceptible to disease, thus epidemic disease following disasters are commonplace. In addition, the breakdown of public sanitation in disasters further accelerates disease transmission through the source-pathway-receptor model. Crowding in squalled camps further enhances disease by bringing large numbers of susceptible people into close proximity with disease sources and unsanitary conditions. Breaking the disease cycle following natural or human caused disasters is a difficult problem for the military as we are called to provide humanitarian relief to refugees and displaced people all around the world.

3. Oceans:

The oceans are considered as an environmental security issue primarily because of their part in feeding the world's population and regional economic importance of fishing for some countries. Annual fish harvesting increased from 22 million tons in 1950 to just over 90 million tons in 1995. This was down from a peak harvest of 100 million tons in 1989[43]. There are indications that overfishing in many regions of the world has caused these recent declines. Fish now represent 20 % of the protein consumed by humans and is the primary source of protein for more than 1 billion people[44]. The increase in collection is caused by the increased demand as populations grow and increased per capita use as fish is substituted for other meat sources that have become more expensive.

A secondary impact of the water quality issues described above is damage to the estuaries: which then reduces the production of food for the oceans. Discharge of domestic and industrial sewage into closed waters such as the Mediterranean Sea is also reducing the number of fish in these waters.

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[43] Alan Gettis and Gettis, Arthur, Introduction to Geography. (McGraw-Hill, 1998), 429.
[44] Ibid, 427.

Chapter 4

STRATEGIC ANALYSIS

A. Introduction

Today, the United States of America is the world's preeminent superpower, whether we use military or economic power as our metric. We are also the world's largest consumer of energy and other natural resources, and the world's preeminent generator of waste. We alone generate more municipal solid waste, trash, than the total from the next 15 developed countries of the world together[1]. In negotiating policies for global warming the United States has attempted all manner of clever data manipulation to hide its consumption of fossil fuels and production of greenhouse gases (see Table 3 – 2, page 3-25) from the world, but all disguises have failed to conceal that we are, far and away, the world leader in greenhouse gas pollution, not a #1 we should aspire to. The cartoon in Figure 4 – 1 really says it all, the fat cat driving the gas hog sits judgmentally over the developing world in 'protecting the environment' (cultural illiteracy is also evident). Our view of ourselves is as good guys trying to do the right thing for the rest of the world – provide peace, have a clean environment, and help them establish an acceptable quality of life. The rest of the world views us with less trust, questioning our motivation in helping and supporting them. This is the context for our environmental security study as we search for a coherent policy and strategy. It is critically important to recognize that environmental security is only a component of the larger process of U.S. foreign policy and cannot be separated from the whole. Foreign policy issues are outside the scope of this research, as is much of the detail of how our Department of State should

[1] Rodney White, North, South, and the Environmental Crisis, (U of Toronto Press, 1993), 148.

FIGURE 4 – 1

Environmental Security, Two Perspectives

SOURCE: Scott Willis, San Jose Mercury News, Copley News Service; 1989.

accomplish its environmental security mission. This study will stop at the point of separating the overall requirements into military missions and those governmental actions best accomplish by other agencies. Recalling from our opening questions, its time to address:

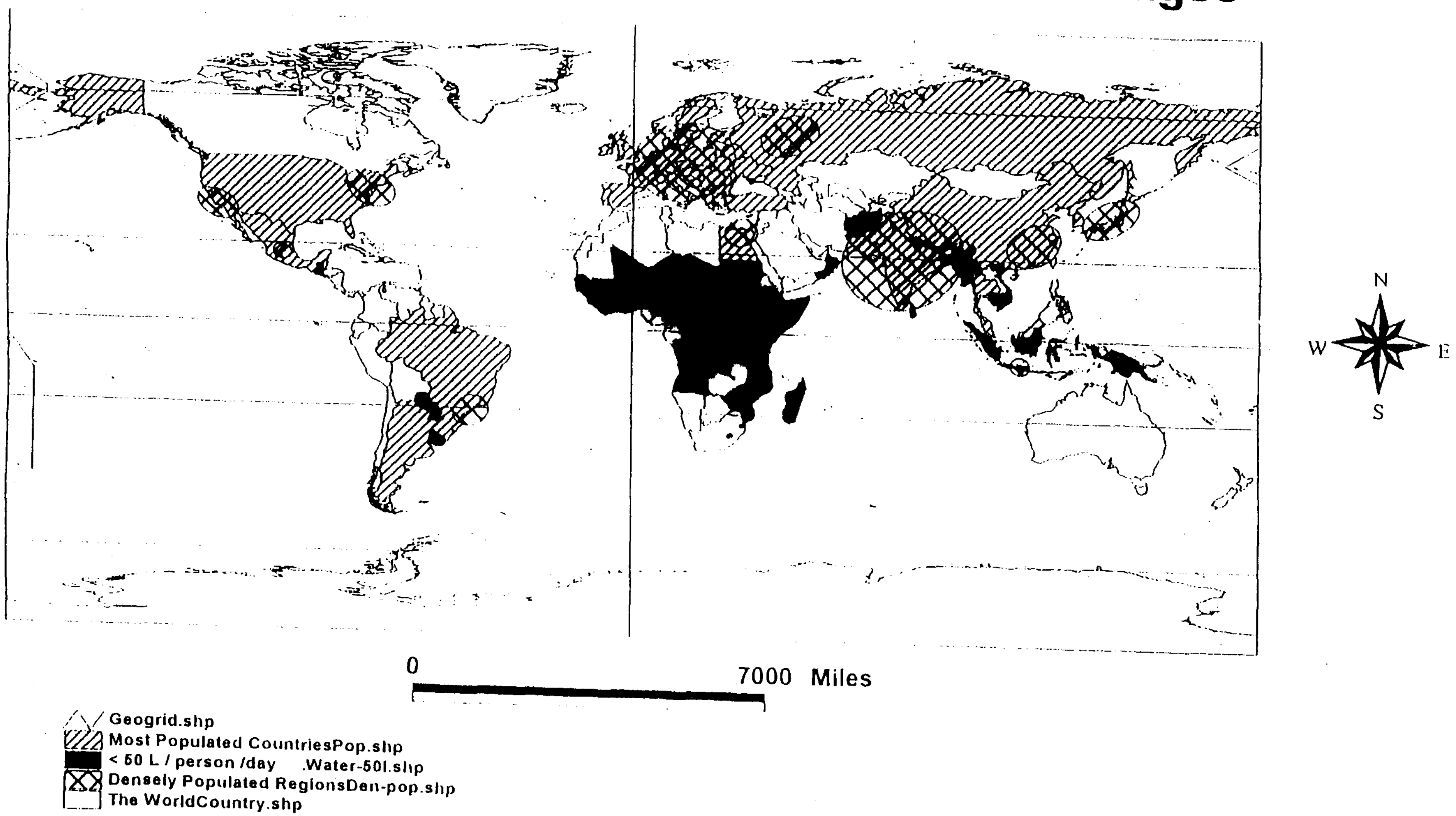
What is the military mission in environmental security and how should we be executing this mission?

In Chapter 1 we visited the current discussions and research focused on explaining the political science of environmental security, while in Chapter 2 we developed a working definition of environmental security for this project. We exited this part of the study with several key consensus based preconditions, which will now allow us to achieve the purposes of the report without making radical assumptions within the numerous areas of uncertainty that remain. The take away lessons from the body of environmental security studies examined include:

1. Environmental scarcity is impacting human lives in many regions of the world. In an address to the International Conference on Climate change in 1994 Eileen Claussen, the Senior Director of Global Environmental Affairs for the National Security Council stated. "*The four resources most likely to help produce conflict are cropland, water, fish, and forests.*"[2] As we saw in Chapter 3, all of these have roots in basic environmental degradation and scarcity issues.
2. Environmental scarcity fostered by a combination of population growth and resource depletion has already been a cause or a contributing factor in regional conflict[3]. The conflicts in the Sahel region of Africa (Chad, Ethiopia, and Sudan), the Bangladesh-Assam fighting was a resource depletion driven migration that produced ethnic conflict, the Senegal River conflict, and to many the ethnic cleansing of Rwanda, all have environmental scarcity roots.
3. The environmental conditions that enflamed the conflicts mentioned above are only getting worse—there is less water, less arable land, fish resources are

[2] Eileen Claussen, International Conference on Climate Change, Washington, D.C. July 1994.
[3] James Lee, Inventory of Conflict and Environment, (AEPI, 1999).

FIGURE 4 - 3
Densely Populated Countries with Water Shortages



SOURCE: Peter Gleick, The World's Water, 1998; populations from Goode's World Atlas.

heavily mined, and deforestation continues--- while regional populations burgeon.

The very useful scholarly debates concerning the cause and effect relationships between conflict and environmental issues will continue, but this project needs to pragmatically move past this discussion. Recall, we established early in this project that we would employ the concepts of risk assessment in dealing with uncertainty in our study. This approach allow us to make decisions without knowing what will happen, but based on the best scientific judgements of what is most likely. Applying risk analysis to the three preconditions above, we can conclude that the risk of destabilizing events or conflict is high today and expected to increase. The harm, which is the threat to long-term U.S. security, manifested by the occurrence of many of the sufficiently likely conflicts would be significant. Therefore, following a risk model where magnitude of harm times probability of occurrence equals risk, high potential risk necessitates that our security strategy focus on preventing and responding to the potentialities of environmental security. This is the approach taken in most aspects of our national security strategy: we regularly employ a risk based threat analysis as the basis for our decisions on policy and strategy.

B. Environmental Security Threat Assessment

Analysis of the threat posed by environmental degradation can be simplified into three questions – what is going to happen, where is it going to occur, and when will it start? Unfortunately, the answers are not going to be as straightforward. First recognize that environmental security is a very contextual issue. For example, assume two disputes over a water rights exist between the United States, and Mexico on one border and Canada on the other. If the technical details of these two problems are similar, do you think that the nature of the discussions will be the same? Logic supported by numerous examples suggests scarcity of water in the south would make that dispute much more contentious. Further, the prevailing political environment could make the technical details of the issue secondary to the political policy considerations. To reassert and emphasize a previous statement, **environmental security is only a component of the larger process of U.S. foreign policy and cannot be separated from the whole.**

Having recognized the primacy of politics over the military and even science, environmental studies do offer solid intelligence data to allow us to conduct our environmental security threat assessment. To begin, Table 4-1, Impacts of Environmental Change, is a summary of the information developed in Chapter 3 on the possible impacts of the most significant environmental hazards. This along with Table 3-4, Potential Impacts of Climate Change(page 3-45), address the 'What' component of the risk equation and to a small extent the where. Table 4 – 1 stratifies the impacts into the categories employed by Ms. Claussen (farmland, forest, water and fish), with the addition of a column for human impacts. Later in our strategic analysis it will become evident that for military considerations, we must include acute human impacts in our assessment. Table 4-1 further divides impacts into global and regional, of great importance in identifying the appropriate policy and strategy response. Table 3 – 5 divides impacts based on the economics of developed and developing countries and further into the temperate latitudes, outside 20° north or south, and developing countries in the tropics, this because there are no fully economically advanced countries in the

TABLE 4 – 1
IMPACTS OF ENVIRONMENTAL CHANGE

Environmental Issue	Global Environmental Concerns				Regional Environmental Concerns			
	Farmland	Forest	Water / Fish	Human	Farmland	Forest	Water / Fish	Human
Global Climate								
- Warming	Inundation of arable lands, drier soils in summer	Change in shape of temperate and tropical forests	Weather changes impact the hydrologic cycle	Natural hazards Property loss, heating & cooling costs	Wetter wet seasons, drier soils in dry season	Shifts in size and location of temperate and tropical forests	Changes in rain patterns, change temporal and spatial distribution	Increased disease in developing countries
- El Nino	...	....	...	...	Increased erosion	Change in water distribution	Increased winter rains, loss of fish in Pacific	Flood and other natural hazards
- Ozone depletion	...	UV damage to many species of plants & animals	...	Cancer	Southern Hemisphere impacts	UV damage to many species of plants & animals		Cancer in Southern Hemisphere
Land Issues								
- Deforestation	...	Greenhouse gases produced, less CO_2 recycled, loss of biodiversity	Reduces groundwater recharge, siltation of streams	Endangers indigenous tribes, biodiversity lost	Temporary increase in cropland	Net loss, particularly in tropical forests	Decreased groundwater recharge, increased runoff rates	Loss in Indian habitat in rainforest
- Desertification	...	...	...	Displaces herding populace	Loss of productive lands	Encroachment on fragile forests	Reduced soil moisture, can increase runoff & reduce recharge	Migration of African nomads
- Waste disposal	...	...	Contamination of surface & ground water, and fish	Toxic exposure	...	...	Poisoning of water supplies & fish	
Water								
- Quantity	...	...	Fresh water fish lost, reduced productivity in estuaries	Creates migration	Reduced irrigation and grazing	Highly variable impacts by regions	Fresh water fish lost, reduced productivity in estuaries	Increases migration
- Quality	...	...	Toxicity and bioaccumulation of toxics	Increased rates of disease	Salinity reduces productivity	Acid rain damage	Toxicity and bioaccumulation of toxins	Disease increases in developing countries
- Oceans	...	...	Over fishing is endangering stocks	Loss of fish, disease exposure	...	...	Over fishing is endangering stocks	Loss of fish

tropical belt. These divisions are similar to the North and South approach of White[4] and others, which defines the rich northern temperate world as one group and the tropical and southern temperate developing countries as a second group. The shortcoming of the North and South approach that we have attempted to overcome with our divisions is providing a place to address the northern temperate developing countries. In the context of environmental security there are important countries in this classification, the Balkans and some of the small states of the former Soviet Union are examples.

These two tables do allow us to draw numerous summary conclusions about the impacts of environmental degradation and change, including in order of importance:

1. Humans are threatened by loss of water and food, and increased incidence of disease.
2. The largest overall impacts from all environmental change will occur in the tropical countries, which are all developing economic countries.
3. Global warming with its linkages to deforestation is the issue with the potential to produce the most damage.
4. Weather change is likely to produce increase in the incidence of natural hazards, and environmental degradation is putting many more people at risk to the wrath of the weather.
5. Overall capacity to feed the world is being reduced by a combination of factors represented in Table 4-1.
6. Water is a major stress factor on human subsistence and economic development.[5]

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[5] Ambassador Richard Armitage, Lecture presented at the Naval War College, May 2000.

The next level of analysis from the summary data available involves conducting a geographical information systems (GIS) analysis of the issues data to determine "Where" environmental security problems and conflicts may occur. The GIS process is a powerful method of employing spatial data to identify trends and summary factors. It begins by thematic mapping environmental data at a constant scale, recognizing that edge errors may exist because most data is constructed following political boundaries while the issues spill across borders based on the physical and human geographic setting. Information can then be overlaid or stacked to identify points of conformity between features or values. In our data analysis population density and rate of natural increase[6] will always be our base feature. In environmental security studies, the only true common ground among researchers is strong consensus belief that population is a primary variable in understanding all the other issues. In our first GIS analysis, we take the water scarcity data from Table 3 – 6 and input it into a thematic map to produce Figure 4 – 2. We next overlay the data from Figures 3 – 2 with Figure 4 – 2 to yield Figure 4 – 3, densely populated regions with water scarcity. Analyzing this figure suggests that the Ganges River area and island nations in southwest Asia are areas where water is a growing concern. This somewhat a surprising finding because many of the areas fall within the wet tropics. When we consider the data on urbanization from Figure 3-4 we can better understand the problem, its too many people in one place and a growing rate. Study in detail reveals that many factors in combination are creating this problem, but it summarizes to the cost of supplying clean water to a fast growing population is our of

[6] Rate of natural increase is the crude birth rate minus the crude death rate expressed as a percent value.

FIGURE 4 - 4
Correlation of Population Growth Rates with Water Scarcity

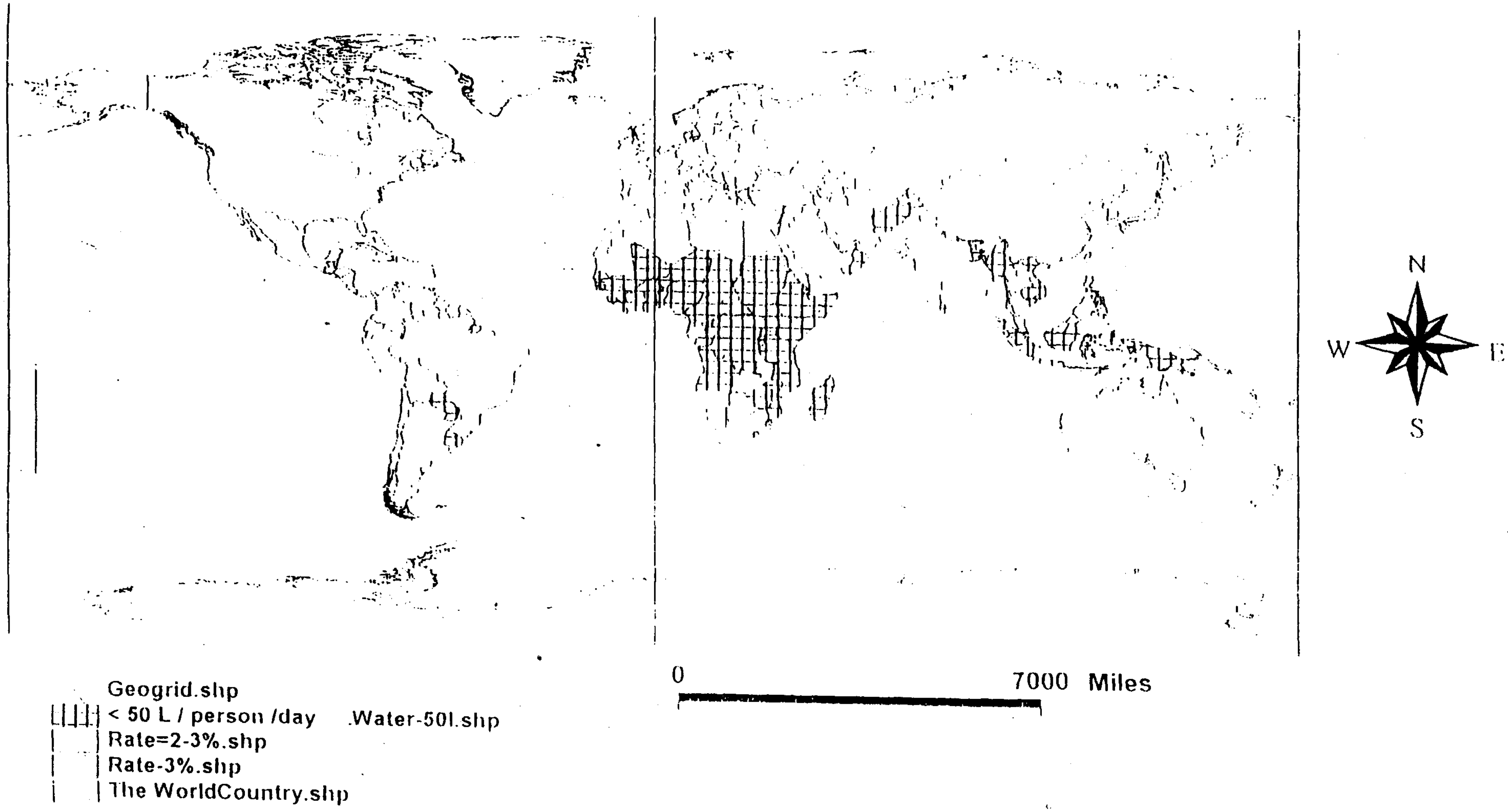


FIGURE 4 - 5
Countries with High Population Growth Rates
and Water Scarcity

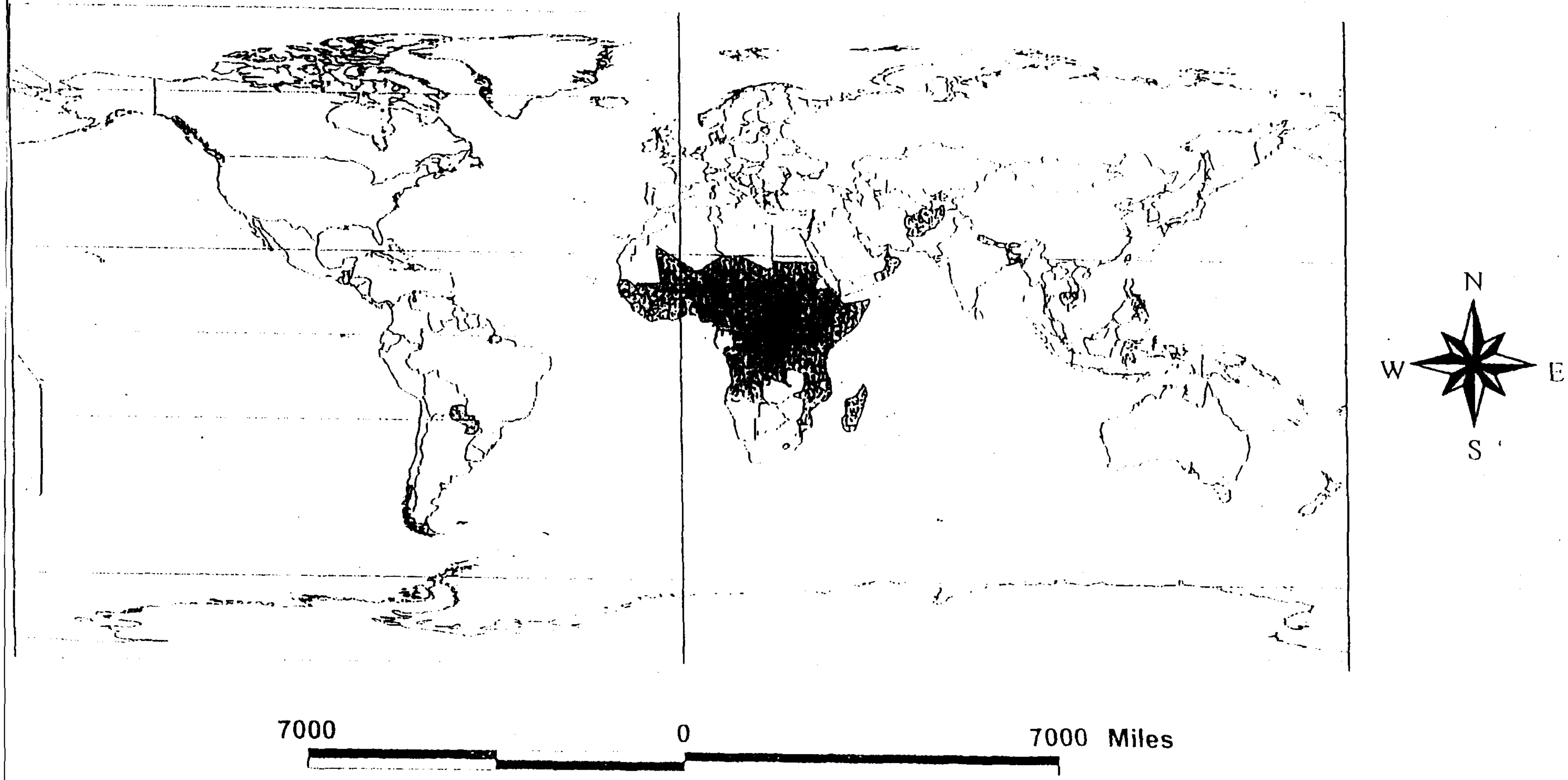
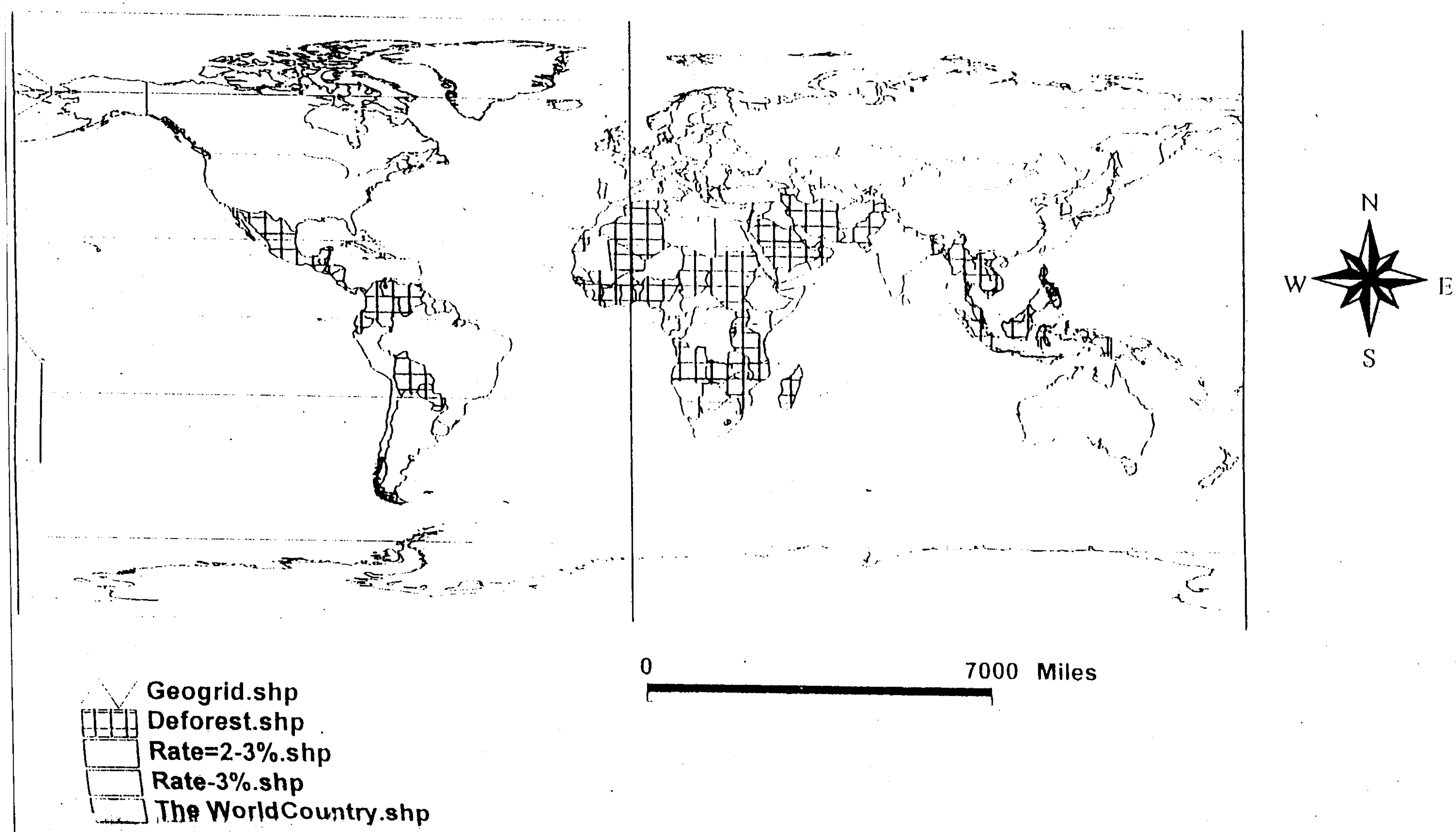


FIGURE 4 - 6
Correlation of Population Growth Rates with Deforestation Rates

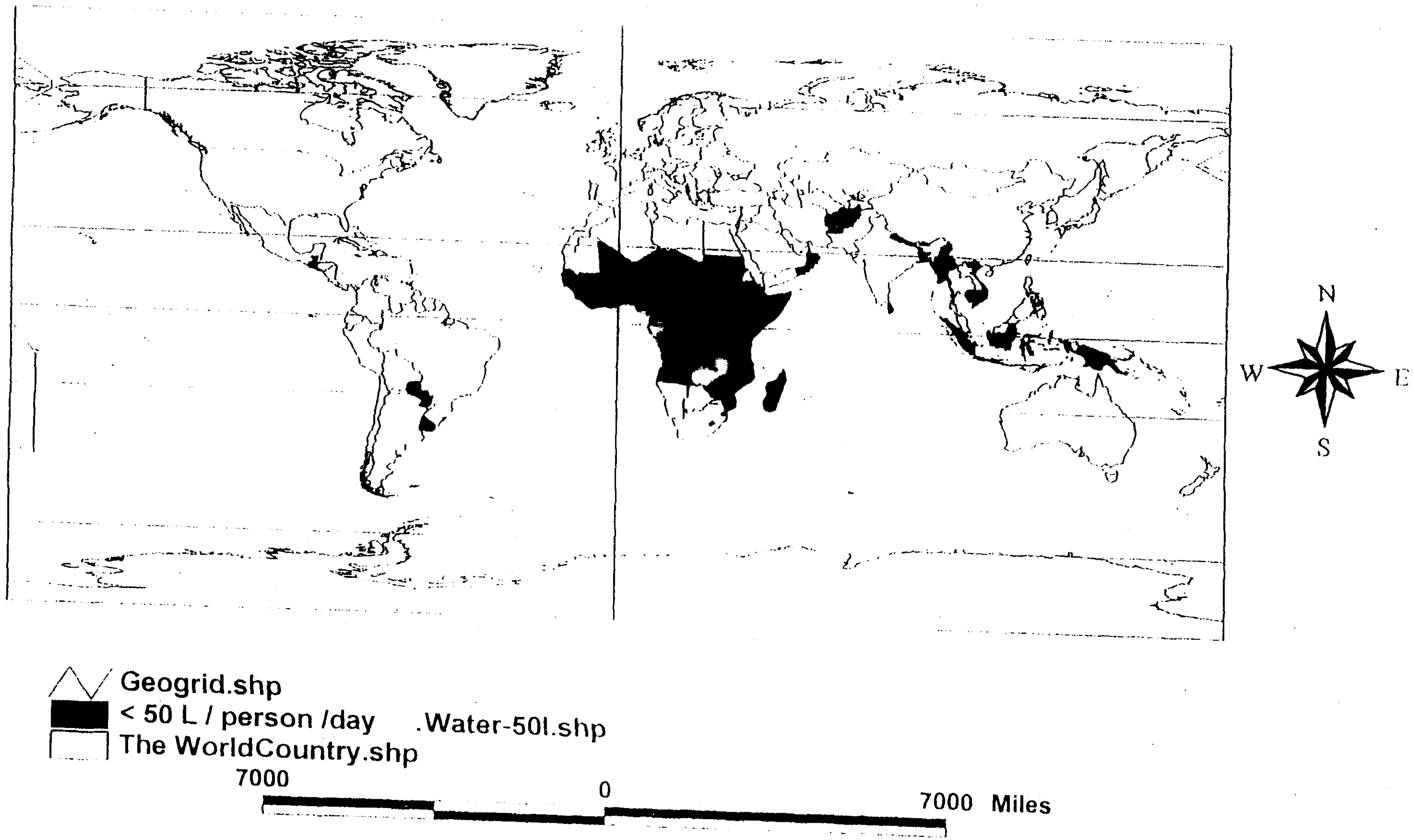


reach for these regions. In many of the island nations, supply is more of the water problem.

There is a concern with this analysis because of the lack of correlation between the places of high population density and the places with water scarcity. Based on these initial results it was felt that rate of population growth as measured by rate of natural increase may prove a better metric than population density. To test this theory the data from Figure 4 - 2 was stacked with the population growth rates data from Figure 3-3 to yield Figure 4- 4. Here we see a much stronger correlation: countries with high growth rates are to a high degree also the countries with drinking water scarcity issues. This same type of analysis with Figure 3 - 16 would further support this finding, but would add concern from disease because of the sanitation problems in these same regions. We can conclude that population growth rates prove a much better metric of the relationship between population and water issues. To better assess the utility of rate of natural increase to predict water scarcity, Figure 4 - 5 was constructed to show only the countries that met both criteria: 41 of the 50 water scarce countries also have population growth rates above 2 percent per year.

Deforestation is the next major issue that can better understood with the help of GIS analysis. Overlaying population growth rates with deforestation rates produces the powerful correlation seen in Figure 4 - 6. Countries with forests that also have high population growth rates are being deforested at high rates. The correlation in this case is even stronger than seen with water. Nearly all of the points of discontinuity can be easily explained. Most are associated with places that have high rate of population, but do not have forests to cut. Somalia, Ethiopia, and Kenya in Africa and Mongolia in Asia are all

FIGURE 4 - 2
Countries Without Adequate Drinking Water



SOURCE: Peter Gleick, *The World's Water*, 1998.

examples of this seen in Figure 4 - 6. In every other point of discontinuity the countries had moderate growth and moderate deforestation, with both just falling below the thresholds used in building Figure 4- 6. From a global sense our concern becomes the countries in the tropics, Africa in particular because of the high rate of natural increase. In deforestation, our greater concern is with the tropical forests because they are the most significant ecological resources. These are the most diverse biologically and the most useful in mitigating the enhanced greenhouse effect.

The next step in this form of analysis is to determine the regions of the world that will be both water scarce and impacted by deforestation. Figure 4 - 7 depicts the areas that meet both of these criteria. The only caution in interpreting these data is that countries already deforested will not be shown. Ethiopia as an example, has lost nearly all of its forests over the last 50 years, therefore is not shown in red in the figure. The Sahel region of Africa (see Figure 3 - 9, page 3-29), the Ganges River basin, and the tropical islands of southeast Asia are the most highly degraded environments with high growth rates in the world.

Constructing GIS maps for the impacts of global warming is, in the view of this research, too problematic to be useful. We can identify concerns in a generic way. First in global warming is the issue of sea level rise. We know that most of the world's population lives close to or on a coast. Any loss of land is certain to displace few–to-many people, depending on the level of rise. Particularly acute will be the low lying delta regions around the world that support large populations, the Ganges and Nile Rivers as examples. Small sea rise in these areas will produce measurable to catastrophic harm.

Changes in weather and regional climate are the toughest issues to predict, temporally or spatially. If we visualize Houghton's predictions shown in Figure 3 – 9 with the data presented in Figures 4 - 5, 4 - 6, and 4 - 7, we have a basis for discussing issues, but probably not highly useful predictive models. In all of this, the northern belt of the sub-Sahara is the area of greatest concern. It fails to provide basic requirements for a population growing at high rates. The area of east India and Bangladesh is another very resource limited area. Adverse weather and/or sea rise in this area could produce traumatic impacts in this region. Existing monsoon conditions already make catastrophic death from flooding almost routine in this area. Caution should be applied in any sort of analysis based on climate modeling, therefore this discussion is offered as only an example of the process more than the absolute value of the findings. We do know with relative certainty that adverse impacts will be better ameliorated in the developed-temperate north as compared to the tropical and southern temperate countries.

Table 4 – 1 demonstrates that most environmental issues are more regional than global in their impacts. Desertification impacts occur in the regions on the margins of the existing deserts represented in Figure 3 – 13. These impacts are extreme to the populations impacted, but occur in the less populated areas of the world because of the low carrying capacity of deserts. Waste disposal is primarily considered because of its localized secondary impacts on water quality, but there are regions of the world where environmental exposures are producing acute and chronic illness. Parts of the former soviet eastern block have particularly severe environmental health problems. Problems in our oceans result from over fishing and reduction of fish production as a secondary

response to anthropogenic damage being inflicted in the world's estuaries by water pollution .

To review, this section presents a very summary analysis of the impacts of environmental degradation. Since many of the impacts are regionally specific while the data is coarsely girded world data, the methodology established is as important as the reported results. The hope is that regional CINCs can collect and apply data from their areas of operation to develop their specific operations plans.

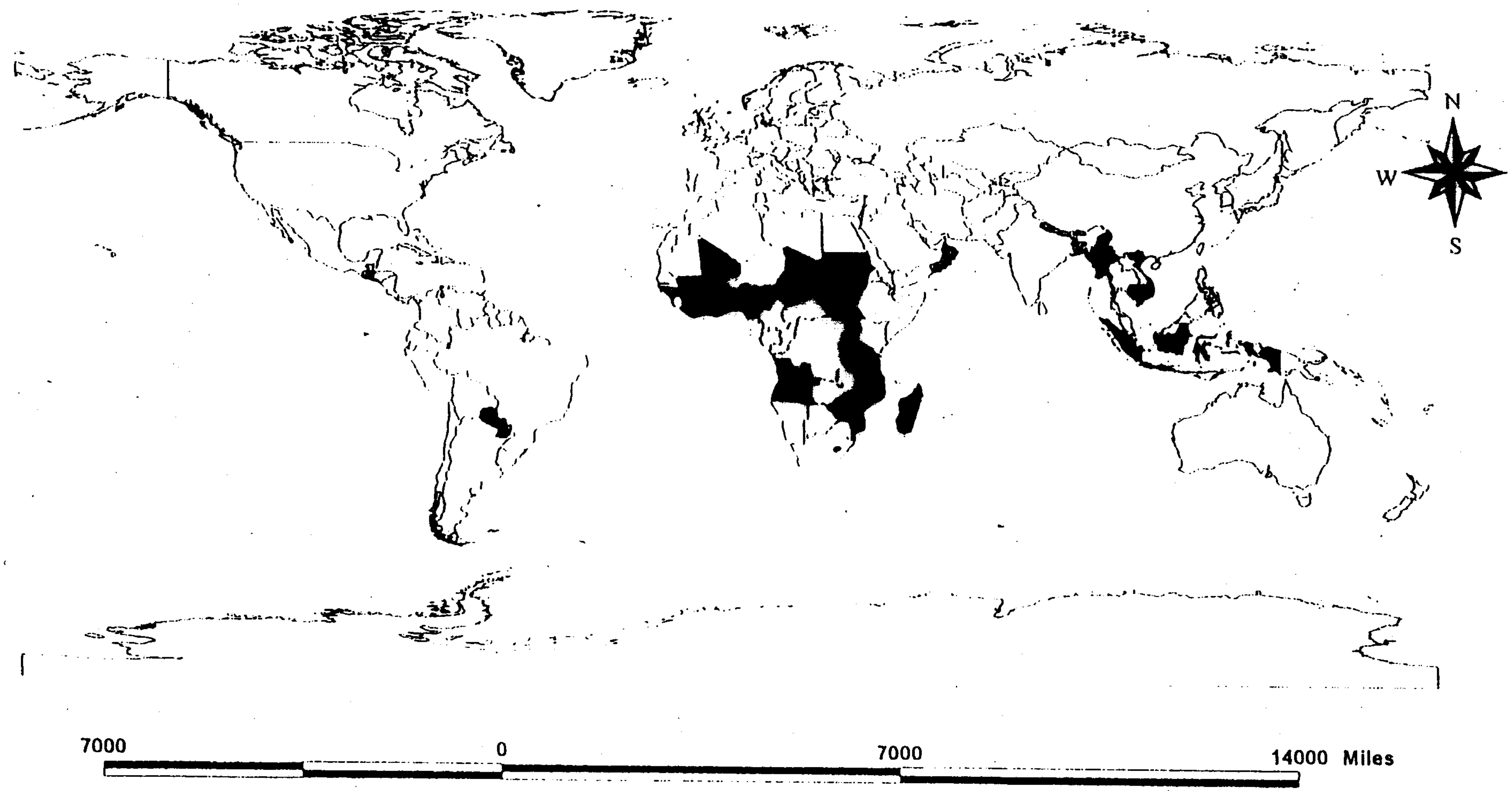
C. Strategic Assessment of Environmental Security as a Military Mission

The fundamental tenant of military power is summed up in the introduction to the National Military Strategy. "*The military is a complementary element of national power that stands with the other instruments wielded by our government*"[7]. The Chairman of the Joint Chiefs of Staff more powerfully expressed the same thought when he stated. "*The military is a great hammer. but not every problem is a nail*"[8]. Following this indefatigable logic. the first task of our strategic military assessment is to differentiate between the military and non-military environmental security missions of the National Security Strategy.

Before beginning this analysis an overview of the applicable national governmental structure to identify the other players in accomplishing the environmental security mission is in order. The framework for developing and implementing U.S. national security policy is reflected in Figure 4 – 8. The National Security Strategy is the primary document promulgated by the National Security Council and the National

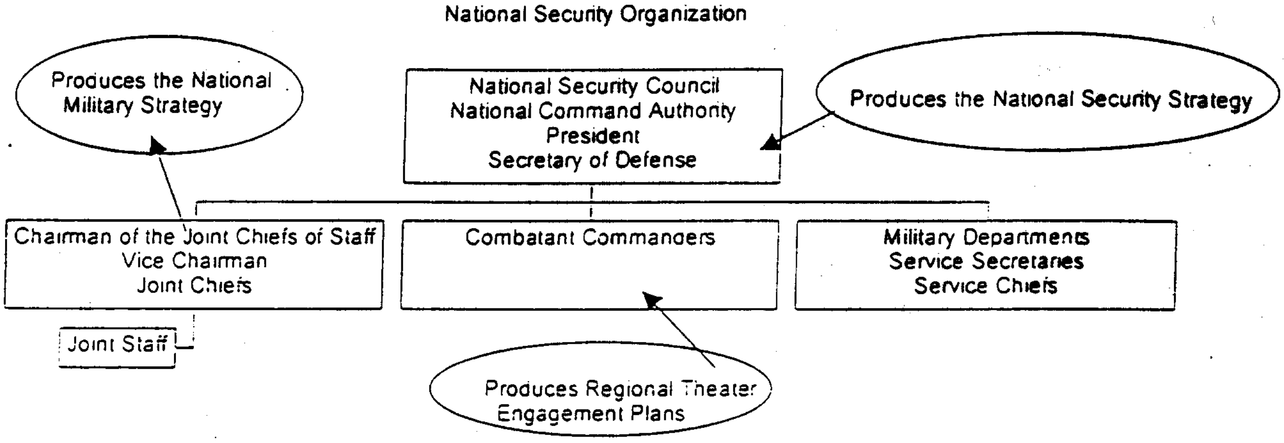
[7] National Military Strategy, 1997, 1.
[8] GEN Hugh Shelton, Lecture presented at the Naval War College. May 2000.

FIGURE 4 - 7
Areas of Deforestation and Water Scarcity



Military Strategy is the accompanying policy document promulgated by the Chairman of the Joint Chiefs of Staff. In the view of this project, this process works well for the policies of the NSS that are wholly military functions, but is inadequate for the policy and strategies required to accomplish the environmental security mission. Accomplishing the environmental security mission requires actions from many departments and offices

FIGURE 4 - 8
National Security Organization

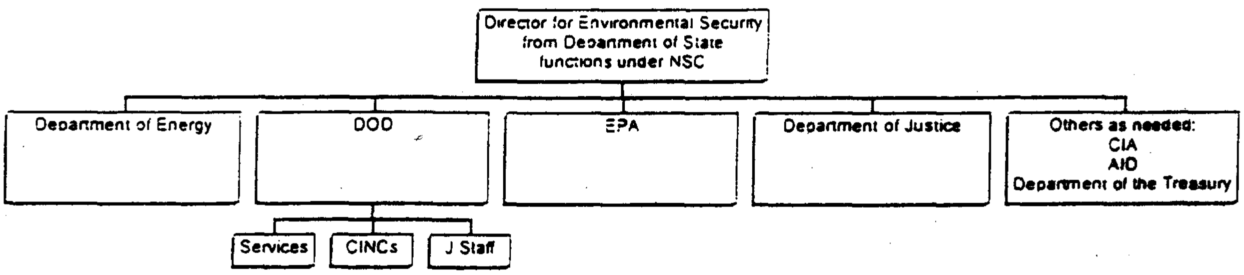


outside the DOD with the bulk of the requirements falling outside the military sphere. In military terms, the DOD should be a supporting activity in developing a strategy and execution of the environmental security operations plan. As we shall establish as the analysis proceeds, the requirements for environmental security are not primarily military, but are fundamentally a matter policy for the Department of State. Figure 4 – 9 presents a proposed flow diagram for environmental security activities within the U.S. government. For the organizations as shown, this indicates both recognition of environmental security as a component of their mission and an existing capability to support this mission. It is evident that no one organization contains all the capability required for developing and implementing a coherent environmental security strategy. It is equally clear that someone must be in charge and the nature of the problem suggests it should be the Department of State. The Department of State in establishing several Regional Environmental Hubs throughout the world shows some recognition of this. Details on the operational art of such a scheme are well beyond the scope of this effort, which remains focused on the DOD activities and functions. This research did not focus on examining State Department activities in support of environmental security, but an interview with Mr. Gary Vest, the Principal Under Secretary of Defense for Environmental Security, indicated that no real plan had been developed by the Department of State, nor had they assumed leadership and management for an overall program[9].

To begin the division of effort, it appears logical that any issues primarily of global focus must be managed from the top of the structure, or by the Department of

FIGURE 4 - 9

Structure for Environmental Security Operations



- The Director is a senior official from the Department of State, working as part of the National Security Council staff
- Each subordinate organization has a member on the Environmental Security Planning and Review Board

[9] Gary Vest, Interview conducted 31 Mar 2000, in the Pentagon.

State in the scheme purposed here. Global warming, greenhouse gas reduction, and ozone depletion are issues falling into this category based on both the data in Table 4 – 1 and the technical explanations presented in Chapter 3. These are issues that must be addressed with the tools of diplomacy such as international/bilateral agreements and economic diplomacy. The international effort to control ozone depleting substances as a great good news example of this process. As Figure 3 – 11 (page 3-37) indicates, we are now seeing a lowering of chlorine in the atmosphere directly because of the international cooperation achieved through the Montreal Protocol of 1987. Protection of the oceans is also primarily a matter of diplomacy, but there are certainly supporting uses of the military, particularly the Navy and the Coast Guard. Waste disposal is another primarily diplomatic and legal activity with little military support involved.

The land use and surface water issues are the areas where the military can have the greatest utility in a supporting role. The next section of this report will delve into some ideas of how military capability can forward the cause of security in a manner preventive defense.

D. Strategic Military Environmental Security Planning

The military approach to accomplish the National Security Strategy is reflected in the National Military Strategy as – "***Shape, Respond, Prepare Now***:..." In shape we seek actions that can prevent adverse effects from environmental change. In respond, we prepare plans and collect information that assures we are ready for all predictable contingencies. Prepare now is manning, equipping, and resourcing for the missions of the future.

The DOD has an office to manage the environmental security program, but this office works under the much broader definition of environmental security from the DOD directive, thus reducing the attention devoted to the aspects of environmental security as it is defined in this work. Further, our analysis (see Table 4-1, page 4-6) showed that the most environmental security issues with military roles occur at the regional impacts level, thus the primary activities will fall under the preview of the regional CINCs. In this context, the **Shape** will come in the actions of the CINC theater engagement planning (TEP) process and **Respond** must come as part of CINC operational planning. It is intended that CINCs can use the concepts of this document to refine these components their mission planning and execution. The Army Center for Strategic Leadership has been a focal point for the DOD in examining the issues for the DOD and actually assisting CINCs in developing environmental security components of their theater engagement plans[10]. **Prepare Now** begins at the national policy level with a plan that can then be supported by the DOD through such an organization as shown in Figure 4 – 9. Until that overarching plan is developed the DOD does not have the guidance it needs to begin its supporting roles.

This leads us to the question which goes right to the heart of the matter of environmental security within the DOD, what actions can be taken by the military to help secure peace? A list of ideas is presented in Table 4 - 2, compiled from much reading and practical experience, wherever it could be found. All the regional CINCs now conduct military to military exchanges. The TEP activities are based on the limited data available to the CINCs, the existing capabilities with the control of the CINC, and

[10] A number of references from the Center for Strategic Leadership, many authored by Dr. Kent Butts, are included in the bibliography as general references that enhanced this research.

money. The costs are not identified as a separate mission related function, but in the general context of winning friends and influencing people. New plans should focus on the kinds of functions listed in Table 4 - 2, with regional analysis defining the priority for the particular CINC. National resources such as Corps of Engineers water resource managers need to be staged and available to regional CINCs. Non-DOD experts in critical skill should also be made available through the overall environmental security project office. Military unique issues such as weapons disposal and green training should be the feature actions of the DOD because that both cover environmental security and building cooperative relationships with other militaries.

In Respond the sequence of events following a manmade or natural disaster is predictable and therefore can be planned for. The overall planning process needs to take place at the DOD level to reduce duplication and address resources, while execution must be planned at the CINC level. We now have a data base from the several responses completed over the last 10 years that can serve as a basis for developing plans. Personal experience and review of the most recent deployments suggests DOD continue to struggle with the same startup problems and repetitive mistakes. Findings this author published in 1994 after the Rwanda mission were similar to reports from Central America after the most recent hurricane.

TABLE 4 - 2

MILITARY ENVIRONMENTAL SECURITY MISSIONS

In the format of the National Security Strategy of 1997:

Shape:

- Military to military exchanges
  - ◊ Land use planning
  - ◊ Green training
  - ◊ Green use of troops
    - Construction of water and sanitation facilities
    - Construction of solid waste disposal systems
    - Preventive medicine and disease control
  - ◊ Educational programs
- Water Resource Management (Army Corps of Engineers)
- Environmental security intelligence gathering
- Disease surveillance
- Military unique environmental protection measures
  - ◊ Chemical weapons disposal
  - ◊ Demining
  - ◊ Explosive waste management
  - ◊ Training lands management
  - ◊ Green training

Respond:

- Operational planning for refugee response actions
- Planning for natural environmental disasters
- Enforcement of international environmental laws
- Operational planning for eco-terrorism

Prepare Now:

- Participate in the development of a national environmental security strategy
- Develop DOD policy and strategy for environmental security to complement the national strategy
- Conduct risk assessment for critical environmental degradation and scarcity issues.

Prepare Now requires an impetus from the highest levels of government. A mission based on the risks described in this work and substantiated by many others including the current Vice President must be developed and resourced. A national level policy and strategy must be developed before military planning can proceed. This process begins with developing an ability to collect intelligence on issues and areas of concern. This research work suggests monitoring of rate of natural increase in countries can predict the potential for environmental degradation; these data are currently readily available. It can be noted that the trouble areas predicted based on this model are very much the same as the hot zone identified by Lee in "Inventory of Conflict"[11]. Given a clear mission and the other elements of Prepare Now listed in Table 4 - 2, the military can effectively accomplish what should be the military component of an overall environmental security program for the United States.

[11] James Lee, Inventory of Conflict and Environment, (AEPI, 1999), 110-111.

Chapter 5

CONCLUSIONS AND FINAL THOUGHTS

A. A Personal Perspective on Environmental Security

At this time in this study I am going to leave the position of independent researcher and resume my normal duties as a career Army officer with 27 years of service and now teaching environmental sciences and geography at the United States Military Academy. My purpose in researching this subject was to combine the two things I do (Army officer and environmental engineer) into a description of the military implications of environmental security. At the beginning of this paper (or book by now) I justified environmental security being a component of U.S. national security strategy based primarily on the threat to stability environmental problems represent. I also discussed supporting rationales based on our high demand for resources and a moralistic view that environmental protection is part of the American ethos. I now freely confess that my personal motivation in my studies and concern with environmental issues is most closely linked to the moralistic view. I truly believe that a clean well-sustained natural environment is part of the heritage we enjoy and should preserve in perpetuity. Believing this, my scientific studies have convinced me that human activities without control will damage our environment on a global scale. In the political jargon, isolationism in environmental protection is not achievable; you can not separate our air from theirs, our water from theirs, or our health from their diseases. We have proven this as environmental issues have evolved from potential risks into to damage control, stratospheric ozone depletion as a case in point. I use ozone depletion as an example because it shows us hope as well as concern. Science came to bear to describe the problem and develop alternatives to the use of CFCs. The international community was able to reach agreements to greatly reduce chorine discharges to the air. We now see a turn around in the concentrations of atmospheric chlorine (Figure 3 – 11, page 3-37)) and fully expect a recovery of the ozone layer with time. I remain hopeful that we can as a nation lead the rest of the world into fruitful discussions on protecting the environment and then set a positive example by practicing what we preach in sustainable development. As a military officer and as a scientist, I see this as the most important element of a preventive defense that we can pursue.

I now set aside my tree hugging leanings and deal objectively with environmental security as defined in this research, which is fundamentally concerned with avoiding conflict. Most who study in the area of conflict agree it requires a set of conditions where people lack or perceive a lack fundamental requirements to sustain their way of life. In the most basic form these are food, shelter, health, and some sense of security. In a higher state, cultural and political influences come into the equation of security. Even lacking these 'basic requirements' people do not always engage in conflict. Usually some initiating activity is required to foment conflict. In our context these may be natural or manmade environmental disasters, migration of environmental refugees, or any number of other environmental degradation events threatening basic human health. This all remains abstract, however, until the concept is actually applied in concrete examples.

Consider first Ethiopia and its continuing state of human suffering and war. Our data shows that it has one of the highest population natural increase rates in the world, has deforested until its fuel wood is almost gone, and is able to provide only 13 liters of water per day per person. There are cultural conflicts in this region and within Ethiopia itself, however, it is clear that a lack of basic human necessities is a primary source of insecurity for Ethiopia and throughout its region. In fact, the entire region is in generally the same condition of resource scarcity. Looking at this area harshly, occasionally shipping food, water, and medicine into this region will never solve anything because it fails to address the root problem of the carrying capacity being outstripped by the population.

One other example that the U.S. and the DOD can identify with is Haiti. Our intervention was necessitated by a political unrest in the country, but many knowledgeable on Haiti identify the causes as fundamentally environmental scarcity and degradation issues. Again, we begin by assessing the available data. Haiti has limited water supplies providing only 30 liters of water per person per day, is completely deforested, has poor sanitation, and is a densely populated country with a high natural increase rate. There are no worse a set of environmental scarcity and degradation conditions anywhere in the world. We entered Haiti to restore security. We found this impossible in a country with these prevailing environmental conditions and thus we struggle to extract our military from the continuing chaos.

To me, the only unknown about the cause-effect relationship of conflict and environmental issues is the size of initiating charge required to set off the time bomb. I look at Sierra Leone, Nigeria, East Timor, Ethiopia/ Eritrea, and most of the other regional conflicts in the world today and I see primary or secondary environmental scarcity issues inexorably linked to each conflict. In summary, common sense, natural science, and political science rarely come together as seen in the unanimous conclusion that environmental security is a topic of importance to the well being of our country and our security.

B. Where Have We Been

I began the technical discussion by defining environmental security based on the goals for this paper. Environmental security as it developed within the academic community encompassed the environmental degradation and environmental resource scarcity issues having the potential to create conflict. This is certainly broad enough to apply to a wide variety of environmental and resource issues, but the military definition went even farther. I believe the definition in DOD Directive 4715.1 is too broad and too far from the primary use of the term outside the DOD. If we, the military, are ever going to address the real security issues emanating from environmental change, the DOD directive must be changed to have focus and clarity.

The second task in this work was to provide a primer describing the environmental issues in laymen's terms. This task is completed with the review presented in Chapter 3. The environmental pollution and degradation issues presented are only highlights from an exhaustive list of environmental topics available. In regional analysis, many of the issues not discussed may be primary sources of insecurity, but this study could not cover all subjects and all regions in detail. The process developed in Chapter 4 can be modeled to collect and analyze additional topics to assess their significance to regional security and stability. From these bases, CINCs can draw conclusions as to what the military can do to support the national strategy for environmental security.

C. What Did We Learn

To begin, the questions posed at the outset were:

What is environmental security?

What is the military mission in environmental security and how should we be executing the mission?

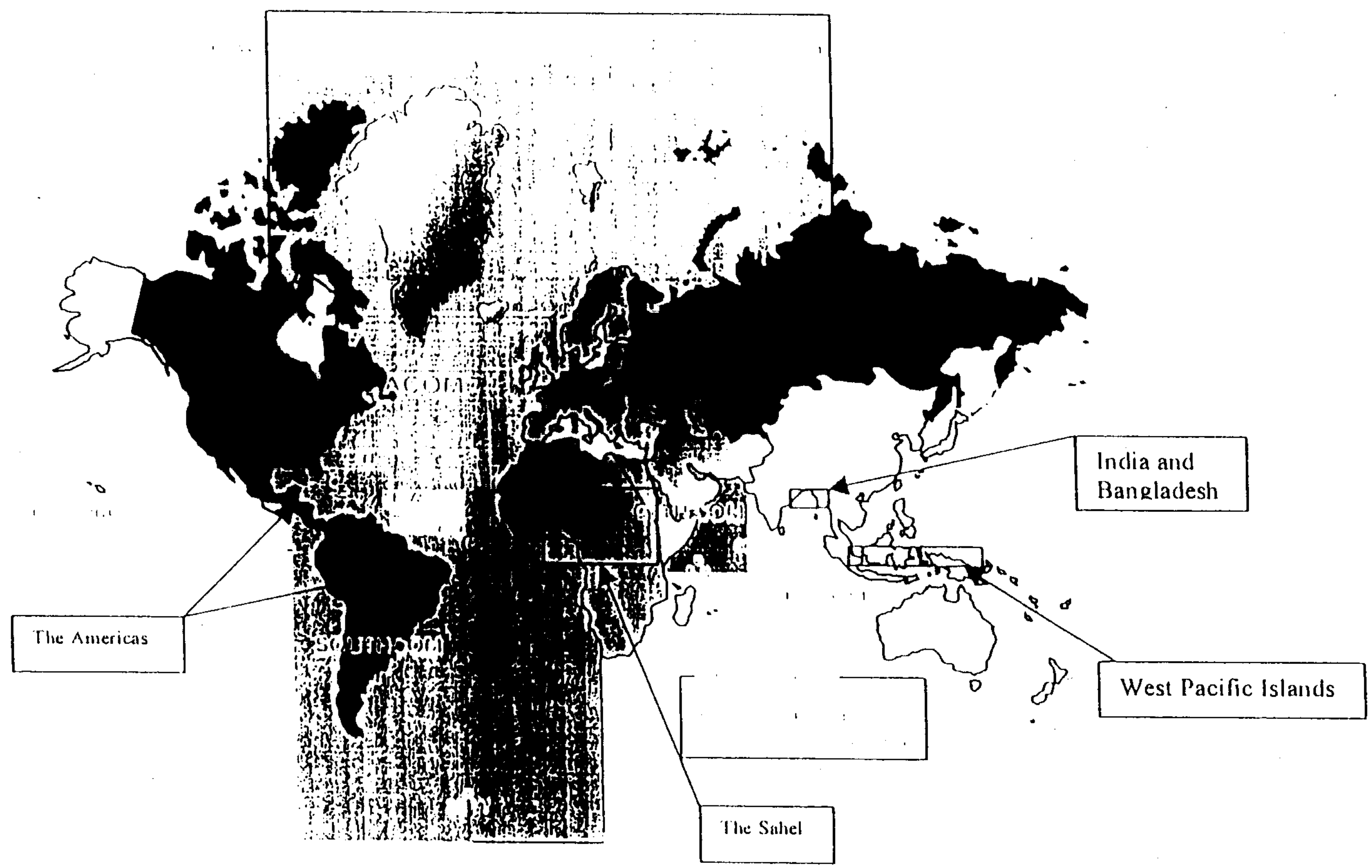
In writing on questions such as these there is a natural tendency, at least for this researcher, to be too grandiose in extrapolating the data further than can be justified. In trying to control these urges, but at the same time represent a vision of how this research can enhance our understanding of the national security implications of the environmental issues, the following overall observations are offered:

- Environmental security is an ill-defined term that means different things to different groups of people. The DOD directive definition is the least precise of all definitions examined, trying to be all thing to all people has left it devoid of meaning for anyone. Environmental security defined conceptually as a process to respond as a part of the U.S. National Security Strategy to those environmental issues having the potential to effect U.S. national security.
- Environmental security is primarily a diplomatic and political function of the Department of State.
- Policy and strategy to address the environmental security requirements of the National Security Strategy are presently not embedded in the governmental structure.
- The military environmental security mission as prescribed in the National Military Strategy is to support the NSS and complement the national environmental security strategy.

FIGURE 5 – 1

CINC Areas of Responsibility

(effective 1 Oct 2000)



- The environmental security issues are environmental resource scarcity and environmental degradation. Critical resources are croplands, forests, water, and fish.
- Population is the independent variable that controls all environmental security issues. ***Rate of natural increase is a good metric to correlate environmental impacts and areas of concern.***
- There are meaningful environmental security missions for the DOD in a supporting role to an overall U.S. environmental security strategy.
- Areas considered of most concern based on a global scale analysis are: The Sahel and central regions of Africa, the island nations of the western Pacific, East India/Bangladesh region, and more isolated areas of Central and South America. These areas are highlighted on the CINCs area of operations map in Figure 5-1.

D. What Should We Do

- A national environmental security strategic policy and strategy is essential before real progress can be seen.
- A structure, supported by resources must be developed to match the goals of our policy and the processes specified in our strategy.
- We need to better leverage existing environmental expertise throughout the government. There is tremendous untapped technical power within the departments of Energy, Interior, Health, and Defense, that could be brought to bear on this problem in a productive and cost effective manner.

- Rewrite DOD Directive 4715.1, to define environmental security based on military policy and strategy to meet the NSS and NMS missions of environmental security and more in line with the non-military world.
- Within the DOD, the environmental security mission must compete for resources through a risk-based analysis. The value added of the environmental security program must be identified and quantified.
- The Theater Engagement Plan (TEP) process is the appropriate vehicle to conduct the military environmental security program. The Manual for Theater Engagement Planning[1] should be updated to reflect environmental security as a component of the process. A program to support the geographic CINCs in the environmental security piece of the TEP process is also needed. The Army War College has is a great start in filling this requirement, but this structure needs to be institutionalized for the entire DOD. The model developed through this research and employed in global analysis provides a useful starting point for detailed regional environmental security assessments.

E. Final thoughts

The second from last question:

Are there environmental response actions required as part of national security policy that should become new missions for our military forces?

[1] Chairman of the Joint Chiefs of Staff Manual CJCSM 3113.01. Theater Engagement Planning, 1998.

Certainly there are areas of expertise where the unique capabilities of the military suggest such missions. The gathering of intelligence information through the use remote sensing technologies is just one example. Civilian research into data analysis for environmental applications is a fast developing field, however, there are complementary issues between research in environmental data gathering and network centric battlefield information systems suggesting the military should consider this as a new mission. This mission would require additional resources because on a risk-based analysis I do not believe environmental security could not replace existing intelligence collection activities in the military priorities for these critically short capabilities. Policing critical environmental resources and agreements is an example where current practice of forward presence could be combined with new missions in environmental security. Many other examples of new missions may emerge as policy and strategy take shape.

Lastly, we leave this study with probably the most challenging question for environmental security.

What in the World (environment) is worth (America) fighting for?

Is it the Amazon rainforests with their biodiversity and ability to mitigate global climate change? Is it some of the world's critical water resources? Is it the ability to possess and burn the oil fueling our economy, but also affecting the global climates? Today, the questions remain in the 'too hard' category of our strategic national policies. Too hard is based on an absence of the certainty we demand, numbers that quantify the impacts on our security produced by environmental change. I remain both an optimist and a realist in this argument. Realistically, humans with their technology have the capability to irreversibly change the surface of the entire planet, for better or worse. The optimist remains convinced that science and technology will provide the data needed to complete our understanding of the earth's processes and we will decide to act to achieve a sustainable vibrant environment. The realistic recognizes change will be necessary and there are significant costs to be paid, but these costs will be cheaper than the costs of not addressing environmental security, soon.

APPENDIX A

A LITTLE SCIENCE

INSIDE THE NUMBERS

Unit of Measure	English Units	Metric Units	Example Areas
Acre	43,560 sq. feet	0.405 hectares	About one football field
Hectare	2.47 acres	10,000 sq. meters	About two soccer fields
Square mile	640 acres (1 section)	2.59 sq. kilometers	A Mall (small)
Square kilometer	247 acres	100 hectares	Small Farm
Cubic meter	264 gallons	1,000 liters	A big box
Cubic kilometer	2.64×10^{11} gallons	1×10^{9} M^3	100 days of water for NY city

TERMS AND ABBREVIATIONS

TERM	DESCRIPTION
AEPI	Army Environmental Policy Institute
AIDS	Acquired immune deficiency syndrome
°C	Temperature measured on the Centigrade
Centimeter	One hundredth of of a meter.
CFCs	Chlorinated fluorocarbons
DOD	Department of Defense
DOE	Department of Energy
DOS	Department of State
CINC	Commander in Chief
FAO	Food and Agriculture Organization of the United Nations
GHG	Greenhouse gases (carbon dioxide, ozone, CFCs, nitrous oxide)
Gigatonnes	One million metric tonnes (2,200 English pounds)

TERMS AND ABBREVIATIONS (continued)

TERM	DESCRIPTION
GIS	Geographic Information Systems
IDHL	Immediately Dangerous to Life and Health
Infrared	Long wavelength energy, heat
IPCC	Intergovernmental Panel on Climate
M^3	Cubic meters
mg	Milligrams, one thousandth of a gram
Micrometers	One millionth part of a meter
MMTCE	Million metric tons carbon emissions
NATO	North Atlantic Treaty Organization
NMS	National Military Strategy document
NSS	National Security Strategy document
PCB	Polychlorinated biphenyls
PPM	Parts per million, in volume for gases and by weight for solids
TEP	Theater engagement plan
Ultraviolet	Short wavelength energy, light
USC	United States Code
USEPA	United States Environmental Protection Agency
Wavelength	Length of the spacing between peaks of an energy wave

APPENDIX B

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